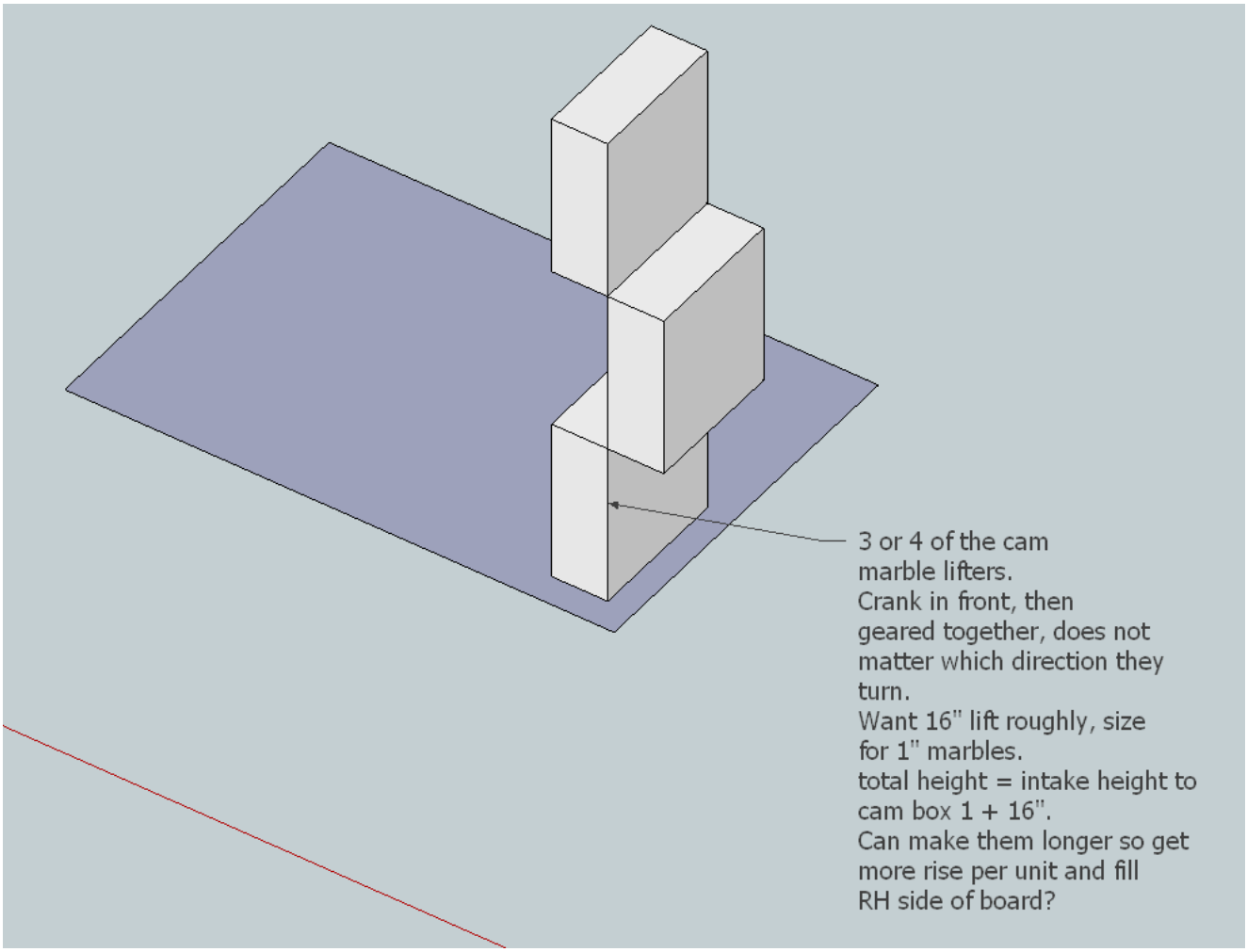
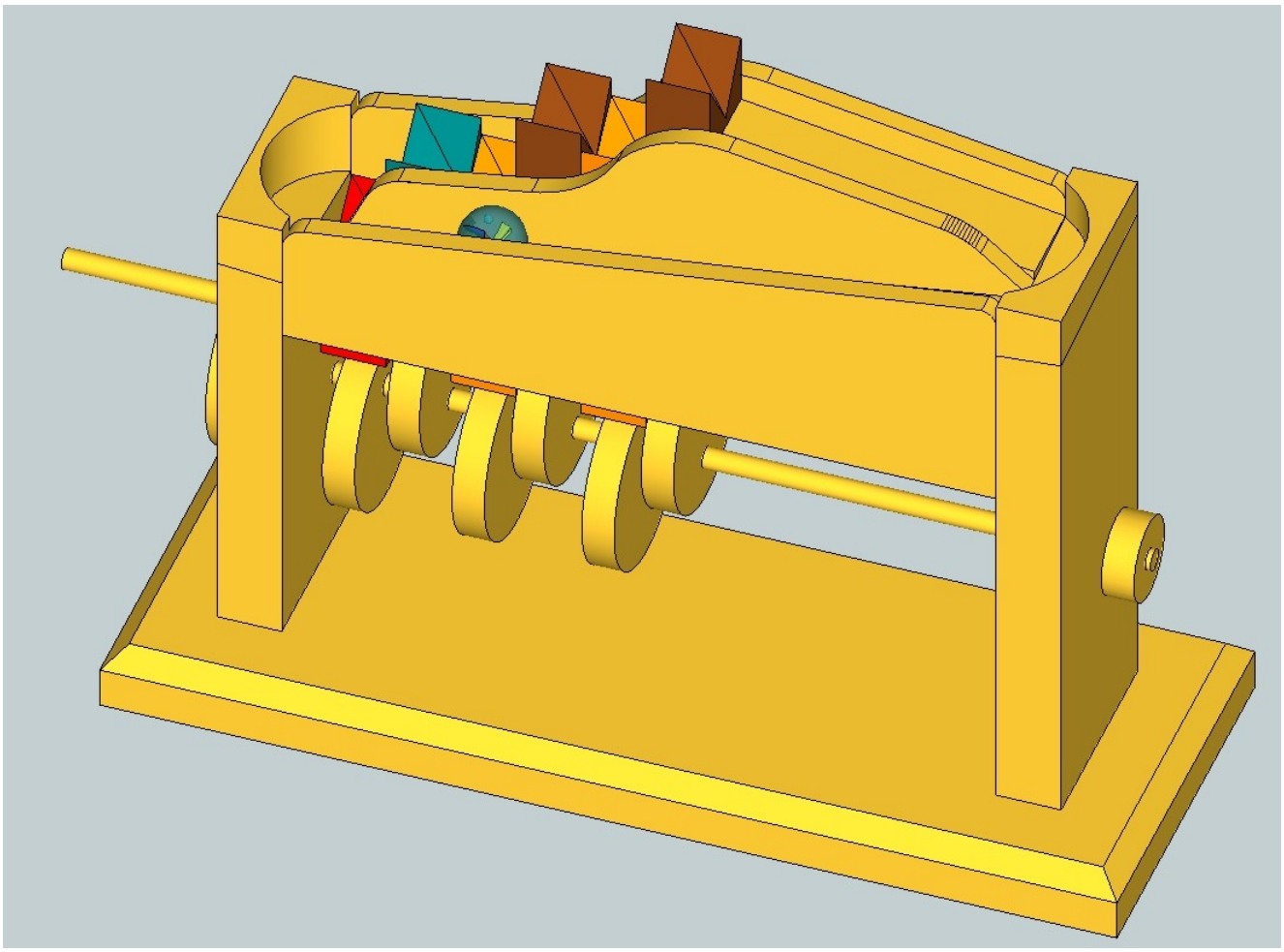
Project to Design and Build a Marble Model that Uses Cams and Lifters

I made several hand-cranked marble machines that used cams to lift the marbles.

Could I put maybe 3 of these together, connected with gearing, that would raise marbles 16”??


3 or 4 of the cam
marble lifters.
Crank in front, then
geared together, does not
matter which direction they
turn.
Want 16" lift roughly, size
for 1" marbles.
total height = intake height to
cam box 1 + 16".
Can make them longer so get
more rise per unit and fill
RH side of board?

I did this first concept sketch on November 27, 2023.



Old Machine

what are cam lengths?

1.75, 2.25, 2.75 so ½” lift per cam

this machine used 5/8” diameter marbles and cams were ¾” thick, or 1/8” bigger than marble…

so, would need 1” + 1/8 = 1 – 1/8” thick cams to run 1” diameter marbles.

6 cams on old model gave 6 times ½ = 3 inches of lift

No, checked SketchUp, distance from entry platform up to discharge platform is not 3,
it is only 2 – 21/64 or 2.33” . I guess you loose some on both entrance and exit (on first cam, slider has to be below the entry platform, and at exit it needs to be above platform.

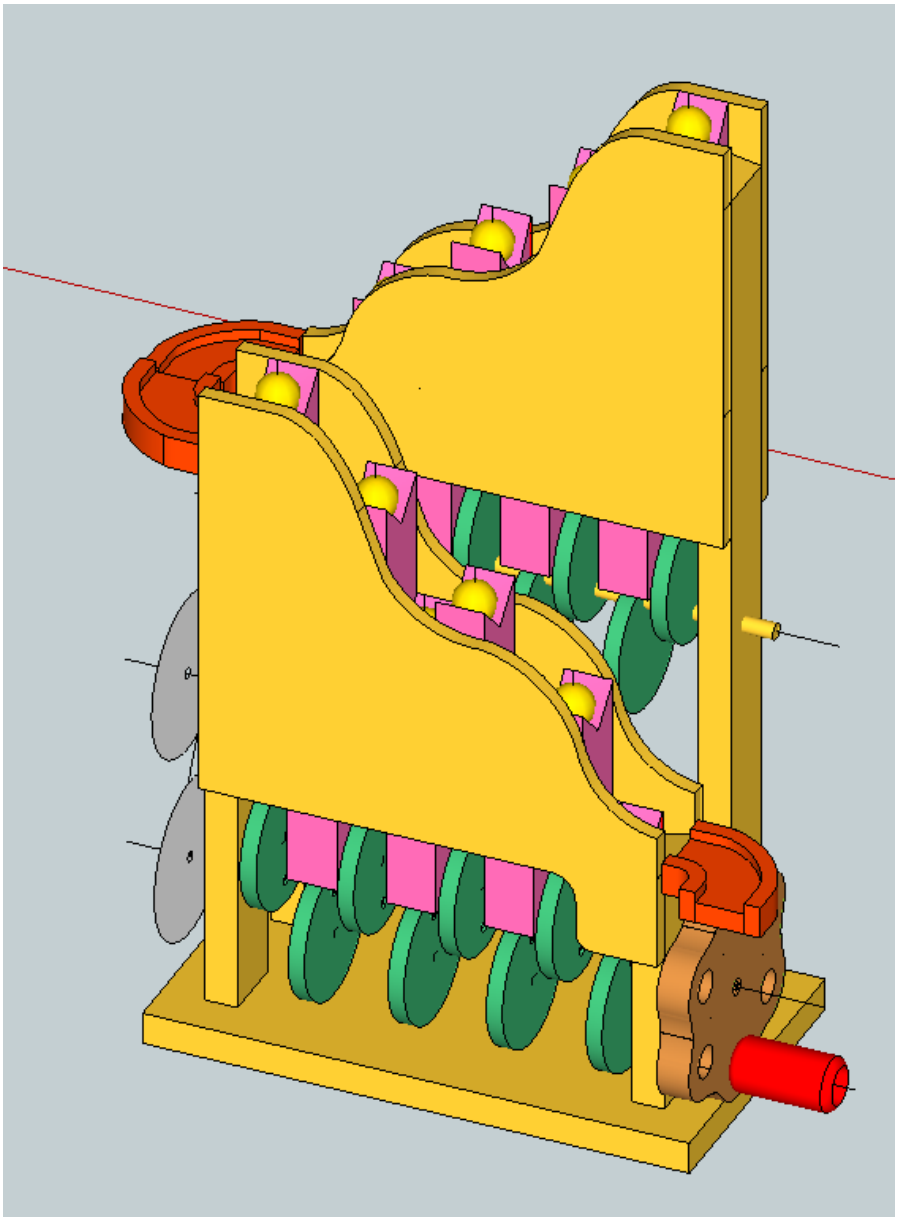
Can add more cams to get more lift.

So old model had ½” throw per cam, why not more lift?? Like ¾” or 1” per cam?

Boy, may have to refresh my memory, if I change the cam and slider designs.

I drew up old cam in SketchUp, total lift of a cam is 1”.

Proof-of-Concept Design



The 4 sides with curved tops are about a foot by a foot. I was going to glue up white oak, or walnut boards, but decided to try using 3/8” plywood to save a ton of work.

Starting to Build Proof-of-Concept Model in the Shop

NOTE: Base board is only big enough for the proof-of-concept, will make a larger one after the proof of concept is done.

Cam Design

Cams have 1-9/16” radius or 3-1/8” OD.

Was going to design them in a spreadsheet, but just went into Sketchup and figured it out.

Each cam will give 2” of lift.

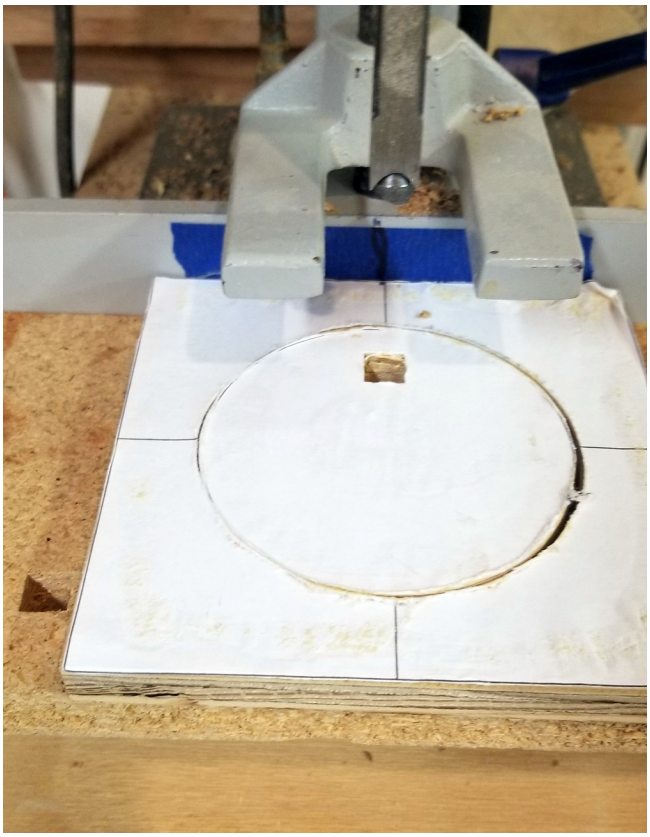
Using Square versus round Crankshaft or Cams

On smaller models I have built, I drilled ¼” holes in the cams, then drove them with a round ¼” dowel, and hot melt glued the cams to the dowel.

It was tough to hold the cams in the right rotation with respect to each other on these past projects.

So, why not try using a 3/8” square shaft to drive the cams? Makes it easy to slide them on and onto position. Can still hot melt glue to hold right position along the model.

Fixture to Mortise the Cams

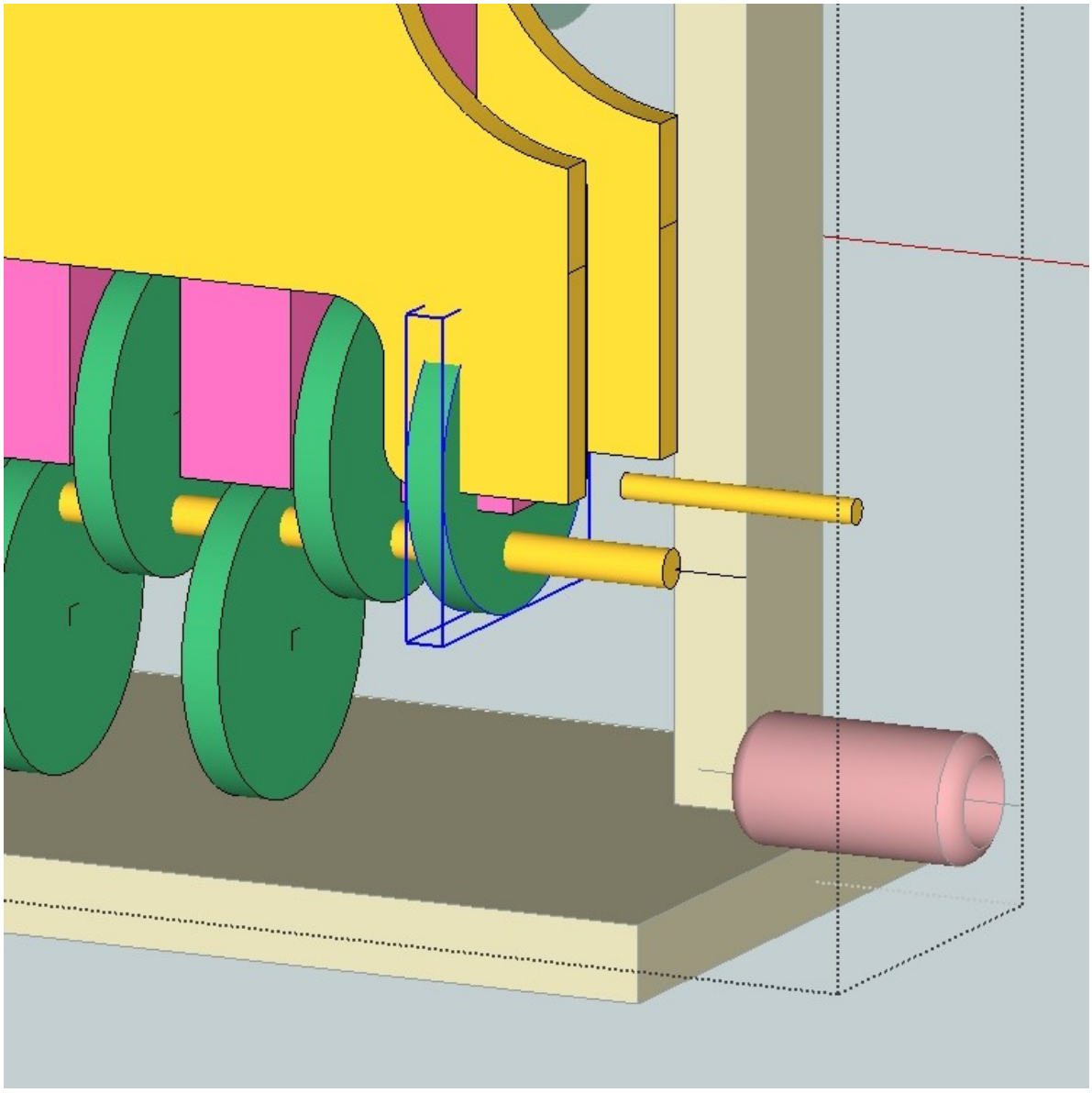


So, I align the fixture piece with the black mark on the blue tape, to make sure I am on center. This fixture also served as a Gage to make sure I made the cams the same OD. I sanded down the cams until they fit in the fixture.

OOOPS _ First Design Mistake

The cams with mortised square holes on a square oak shaft seemed to work OK.

But, my first cam on the crank end is hitting the 2 sides. OOOPS, I did not find that in Sketchup.



Oh well, back to the drawing board :)

How I made the cams

1. Print out paper copy from Sketchup
2. Glue paper pattern onto 3/8” thick plywood
3. Band saw about an 1/8” bigger than the ideal diameter

4. Use either drum sander on drill press, or disc on belt sander to sand down to the line
5. Make sure cam fits in mortising fixture
6. Place cam in mortising fixture
7. Mortise the square 3/8” hole in cam

I chose plywood on these relatively big 3-1/8” OD cams versus solid wood. On these bigger cams, solid wood could warp over time, where the plywood won’t warp. On smaller cams, solid wood has worked OK.

Checking Lifter Design

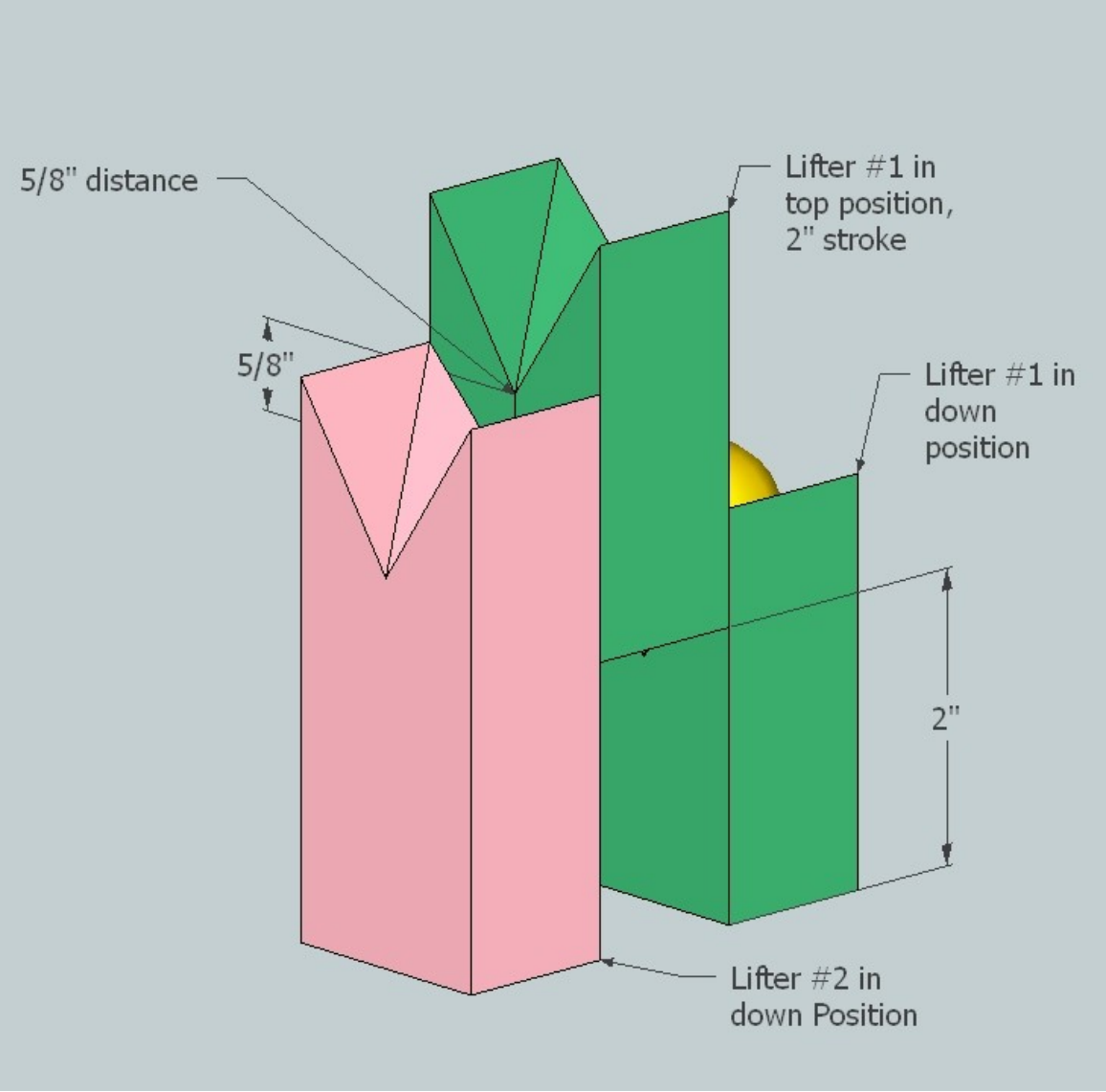
It has been several weeks since I designed the lifter lengths. To make them, I just need the over-all length, then the 2 distances from the bottom of the lifter to the bottom of the notch that holds the marble.

I made a table to take to my shop to crank out these lifters, but then I noticed my over-all length is in even 1” increments, but my 2 other dimensions are not?? Did I not design them right?

cam	over-all length	delta	Short distance, bottom of lifter to bottom of notch	delta	Long distance, bottom of lifter to bottom of notch	delta
1	2 13/16		1 5/8		2	
2	3 13/16	1	2 11/16	1 1/16	3 1/8	1 1/8
3	4 13/16	1	3 5/8	15/16	4	7/8
4	5 13/16	1	4 11/16	1 1/16	5	1
5	6 13/16	1	5 11/16	1	6	1
6	7 13/16	1	6 5/8	15/16	7	1
7	8 13/16	1	7 11/16	1 1/16	8	1
8	9 13/16	1	8 11/16	1	9	1

Went back to Sketchup, found I had made a slight error.

I started over using Lifter #1 and then added cams.



One could argue my 5/8” dimension is too much and maybe it should be about a ¼” ?? On my smaller model using 5/8” marbles I have around 3/8 to a ½”, so maybe 5/8” is about right for the bigger 1” marbles I am using on this project. We will see how it works.

New Lifter Table

Lifter #	over-all length	delta	Short distance, bottom of lifter to bottom of notch	delta	Long distance, bottom of lifter to bottom of notch	delta
1	2 13/16		1 5/8		2	
2	3 13/16	1	2 5/8	1	3	1
3	4 13/16	1	3 5/8	1	4	1
4	5 13/16	1	4 5/8	1	5	1
5	6 13/16	1	5 5/8	1	6	1
6	7 13/16	1	6 5/8	1	7	1
7	8 13/16	1	7 5/8	1	8	1
8	9 13/16	1	8 5/8	1	9	1

Surprises

At this stage, have 8 cams installed and 3 lifters. The lifters are pinched a little at the top because the plywood is slightly bowed!! May have to install an “expander” at the top to keep the sides parallel.

Other than having an interference problem with cam #1 as noted above, and fixing the lifter design details, no big surprises so far !!

Finishing up lifters on Assembly #1

Down to making the last and longest lifter. Been testing as I go, 7 lifters work OK, but may have to make a couple of changes:

1. May have to make 2 small vertical guides for shortest lifter, since not much guide length.

2. Maybe in the middle, lifter #4 or 5, maybe I should make a vertical slot in 1 of the 2 sidewalls, to guide the lifters, so they don’t all tip.

Will crank and test this 1st assembly once I get the last lifter done, then modify until it works consistently.

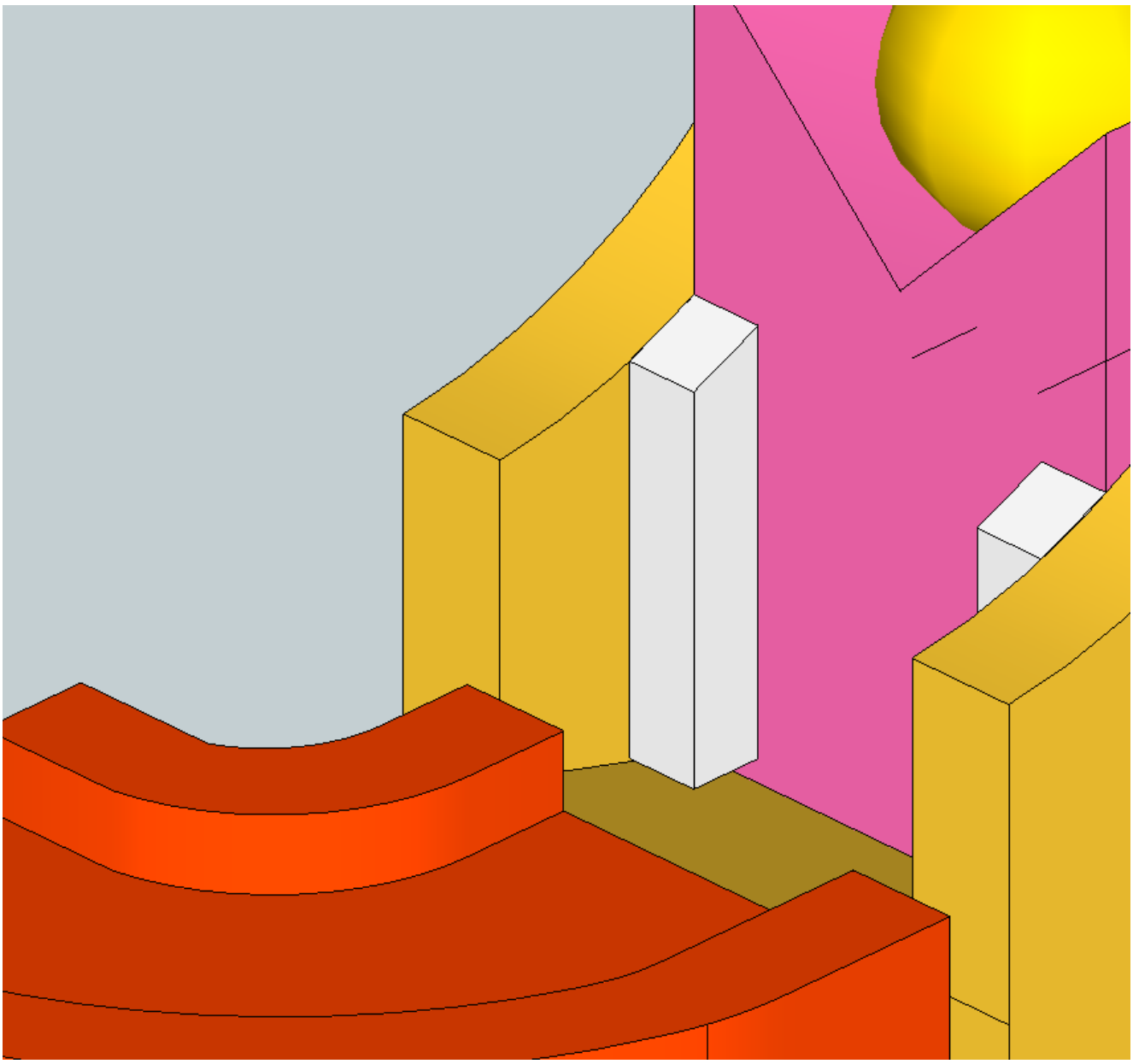
I’m using standard pine for the lifters versus oak. On small models, oak is heavier and helps to give weight to the smaller lifters. Hopefully, I can get buy with pine on this bigger model.

Square to Round Transition on Driveshaft

On the hand crank end, I can probably run the 3/8” square oak shaft into the round crank piece. If this is a little off-center, it won’t matter.
The back end is trickier, because a gear must fit onto this shaft. The gear probably needs to be as close as possible to perfect center on the shaft, because it must mate with a 2nd gear. A future challenge to solve!

Added 2 small guides on input side of Lifter #1

There is not much guide length on this shortest lifter, so easily added 2 guide blocks. One guide is in the C-clamp being glued up.



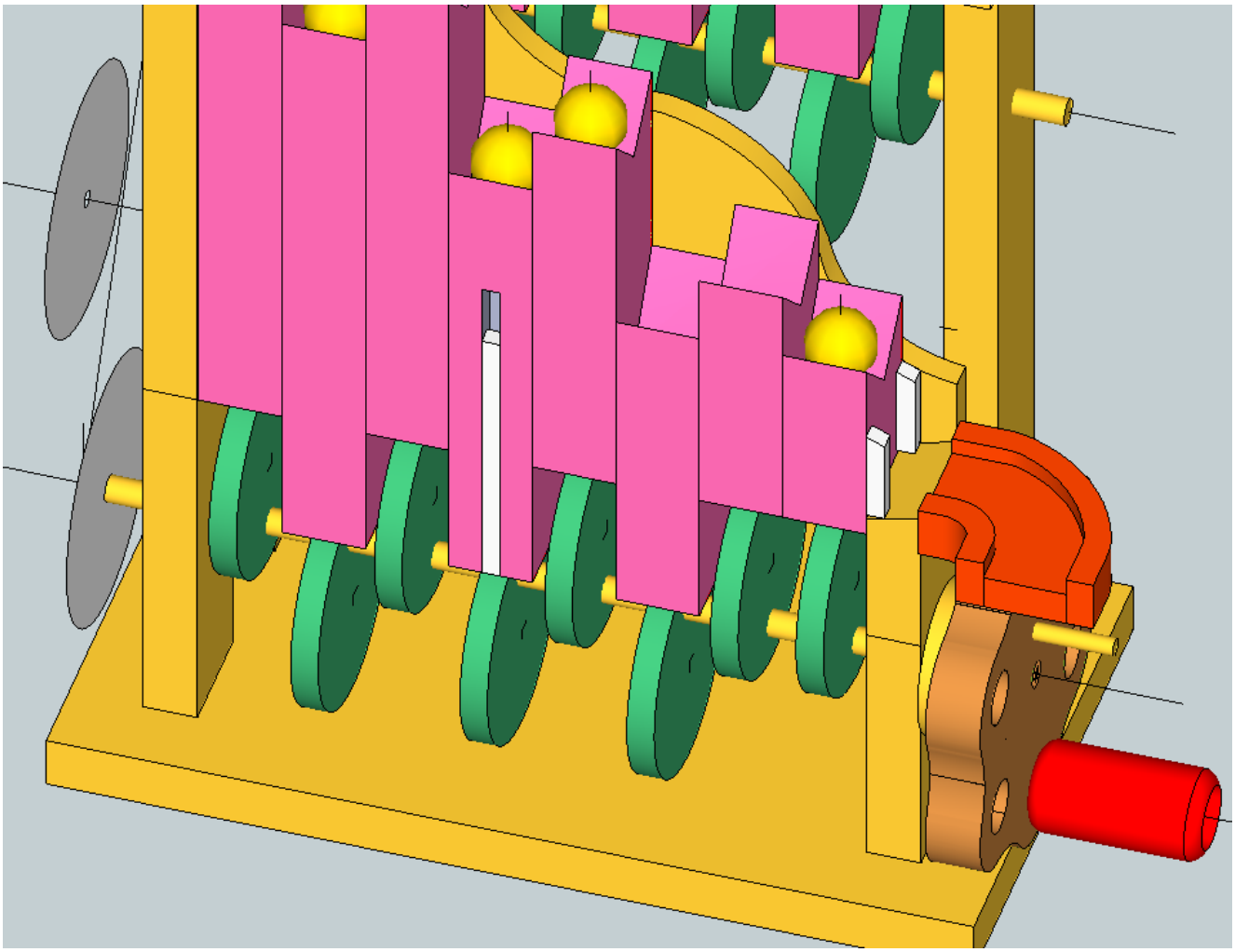
Lifters Wobble Quite a Bit

These lifters are much longer than I used in the smaller models for 5/8” marbles, so they tend to wobble more. So, how to guide a middle lifter?

-Could make a ¼ by ¼ groove in the plywood vertically…..Nope, too hard to do with Router.

-Make the ¼” groove in the side of the lifter…..then glue ¼ by ¼ guide piece on the plywood side?
-should be easier.
-only need on 1 side I think, versus both sides, will have to try it.

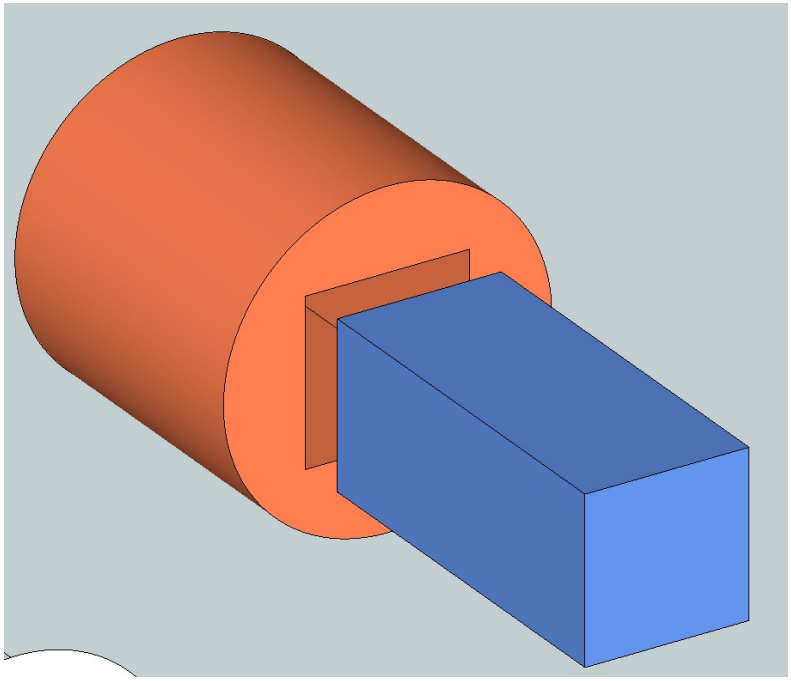
¼ by ¼” square guide for #5 Lifter



¼ by ¼” guide is glued to the outer plywood walls.

Transition from square to round dowel drive

I could mortise a 3/8” square hole in a piece of ¾” OD oak dowel, then oak dowel goes into a gear or the hand crank drive.



Not too much wall left on adapter! How to keep from splitting dowel when trying to mortise it?

¾” diameter radiator clamp ?

How about drilling a ¾” hole in a piece of ¾” thick oak, put in the dowel, mortise the dowel and the board keeps the adapter from splitting??

Well, it worked ! I am a little off-center, but maybe I can get closer with some trial and error on the mortise machine for the gear adapter? This is probably close enough for the hand crank adapter……...or no adapter and just mortise the hand crank?

Adding a 2nd vertical guide to the lifters

The 2nd lifter wants to cock a little bit, which lets the 3rd lifter cock also. So try adding another guide on the 2nd lifter (2nd shortest lifter).

Crank Handle

Decided to make the entry 90 degree elbow and mount it, that will force me to get the handle out of the way of the elbow chute.

I cut the elbow out of ¾" thick pine using the scroll saw. Then I cut the angle in the inner bed with a hand saw and sand.

Boy, I have made a lot of these before on past projects, but I forget how I clamped them up??

Bushing for crank handle

The wheel for the crank needs to be 2-7/8" away from the vertical pillar. I made a bushing out of oak on the lathe. I plan to use 2 wood screws to attach it to the vertical pillar.

Input 90 Degree Chute and Bushing Done

Bolted chute to RH vertical post with 2 wood screws.

Clamped 2-7/8” long bushing to vertical post, then drilled for 2 wood screws. Ran ½” drill through bushing into vertical column, re-assembled and it works great !!

Looks like my original 3/8” square shaft may be long enough to mount the gear on the output side.

Crank Handle Installed

Brain-Fart When Mortising Square Drive Hole in Crank Handle Body

I have always made these from red oak, but I decided to make this one from ¾" plywood.

When I went to the mortising machine, I pulled down on the lever and it quit moving downwards??

I finally checked the machine, and on a previous project I had set the stop bar in such a way that I was now hitting it !!!!!

Adjusted the vertical stop bar, and bingo…….was able to mortise the ¾" plywood with no problems.

Is Crank OK on Square Shaft?

I drilled and put in an 1/8" dowel in the 3/8" square shaft. As long as some tension from the other end of the square driveshaft, it seems to be OK.

Reducing Friction

Friction creates the amount of force required to crank these types of models.

I thought about using balsa wood instead of pine, since you are lifting 8 lifters times 2 assemblies which is 16 lifters. But, the more I thought about it, when you crank, you are trying to lift 4 lifters in 1 assembly, but counteracting this force is the force downwards on the crank from the 4 other lifters, so lifter weight is kind of irrelevant.

So, sanding the insides of the 2 main vertical body plates should reduce friction between the lifters and the sides. Right now, it is just a piece of 3/8" plywood and I have not sanded it with 220 grit yet, but I will. I have already sanded all the lifter surfaces down to 220 grit.

Making a tighter fit on the square shaft to the mortised holes in cams and crank body

The one 3/8 by 3/8" square oak shaft I am using is a little sloppy. I made it on the table saw. I could make a new one, and use my planer to do a trial & error tighter fit.

Sanding

Sanded inside and outside of 2 main vertical body panels on assembly #1. Put back together with lifters, a little smoother, but not a whole lot.

Dye

Tried burnt umber water dye I used on giant log cabin project. Bottles had dried up completely, put a little water in 2 of the bottles and used it. Not brown enough on the 3/8" plywood for me. Will have to get more of it, or buy the powder dye that I have also used before. The powder lasts forever, where the Dr. version does not, it dries up. Dried in the oven.

Adding Cam Unit #2

I noticed I probably have too much fall from the lower unit to the upper unit, it measures about 1.25”. You can see it in this photo.

I'm guessing I need about ½" of fall, not 1.25". If I reduce it to ½", I gain (1.25 - .50) = ¾" of marble total lift!!

I am only about 15" of total lift and my target is 16.

I'm going to try to make a single sweep piece of chute to connect the 2 units. Once I get that built, I will verify I can raise the upper unit about ¾" of an inch.

Math Check

If travel is 6" around the 2 bends and angle of fall is 10 degrees, what is drop?

Z over 6 = tan 10

Z = 6 * Tan 10 = 6 * .176 = 1.0 inches

how about 5 degrees?

6 * Tan 5 = 6 * .087 = 0.52 inches

5 degrees should work.

After making the double bend

½" higher versus ¾" seems about right physically working with the curves.

I made 2 new vertical pieces, a ½" longer each.

I should have caught this when I designed it in Sketchup.

Live and Learn !

Making 2nd Square Shaft

I used the planer method and kept decreasing the thickness until the 3/8" square shaft fit perfectly in the mortise hole in the cams. Works much better than table saw method.

Double-Bend Installed

Houston – We Have a Problem

I made the 2nd square shaft and started installing the cams on the upper level. Tried to rotate cam and it his side body of lower lifter assembly !!!!!!!

I know I check this in Sketchup when I designed it, but I must have screwed it up.

In Sketchup, distance from center-line of square shaft to adjacent vertical body is 2-5/16”.

But, cam distance is 2-9/16”, which gives ¼” of interference. **DARN**

Probably should move 2 vertical legs for 2nd level out about ½" which gives ¼" clearance.

Ended up moving it over ¾".

2nd Set of Lifters

Had same problem with lifters falling over, so going to add the same guides to 2 of the lifters that I did on the lower assembly.

Idea on How to Make the 2 Gears with square shaft drive holes

1. Make the square hole with the mortise first in the blank
2. Use a razor knife to cut out the square hole in the paper gear pattern printed from Sketchup
3. Glue on the paper pattern, and align the square hole to the actual hole in the blank
4. Scroll saw the gears

This will give less run-out of OD of teeth to the square shaft, versus gluing on the paper pattern and trying to his the right exact spot with the mortising machine.

So 2 of the gears will have a square drive and the 3rd center gear will have a conventional ¾" round drive hole for its axle.

Gear Design Concerns

I have several concerns.

1. Will the 3/8" square oak shaft(s) be strong enough to drive the gear train?

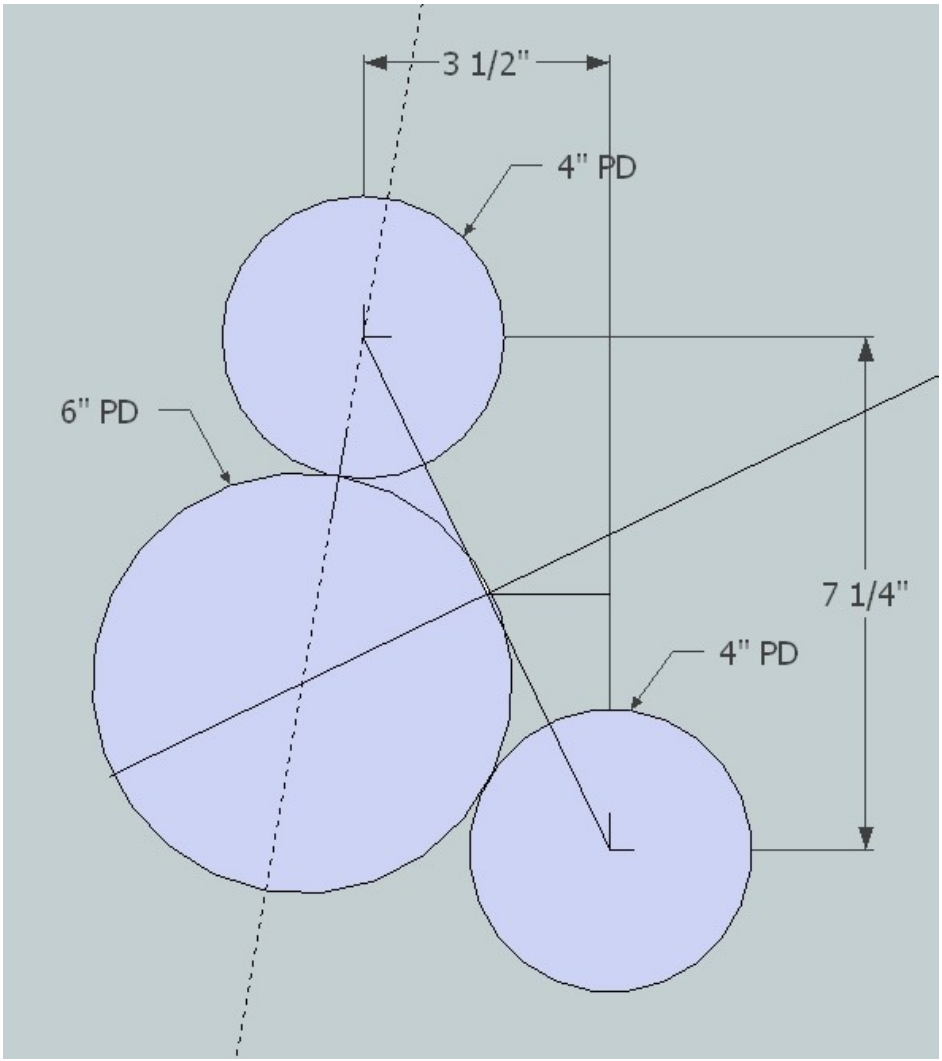
2. Crank friction force is determined by the run-out of the OD of the gear teeth to the center drive axle. Can I get acceptable level of run-out on the 2 gears using the square drive?
   (See above, making the square hole first is probably an excellent idea)

3. The location of the two square driveshafts is fixed. If I tried to make the 3rd gear exactly between the 2 driveshafts, I can't adjust the location of the 3rd gear to get a good mesh. Usually I have to add about 1/16" to 3/32" to the center axle distance to get a good mesh.

   If I make the center gear bigger, I can offset it from the center-line of the 2 driveshafts, and I can adjust the location of the 3rd gear until I get a good gear mesh on all 3 gears.

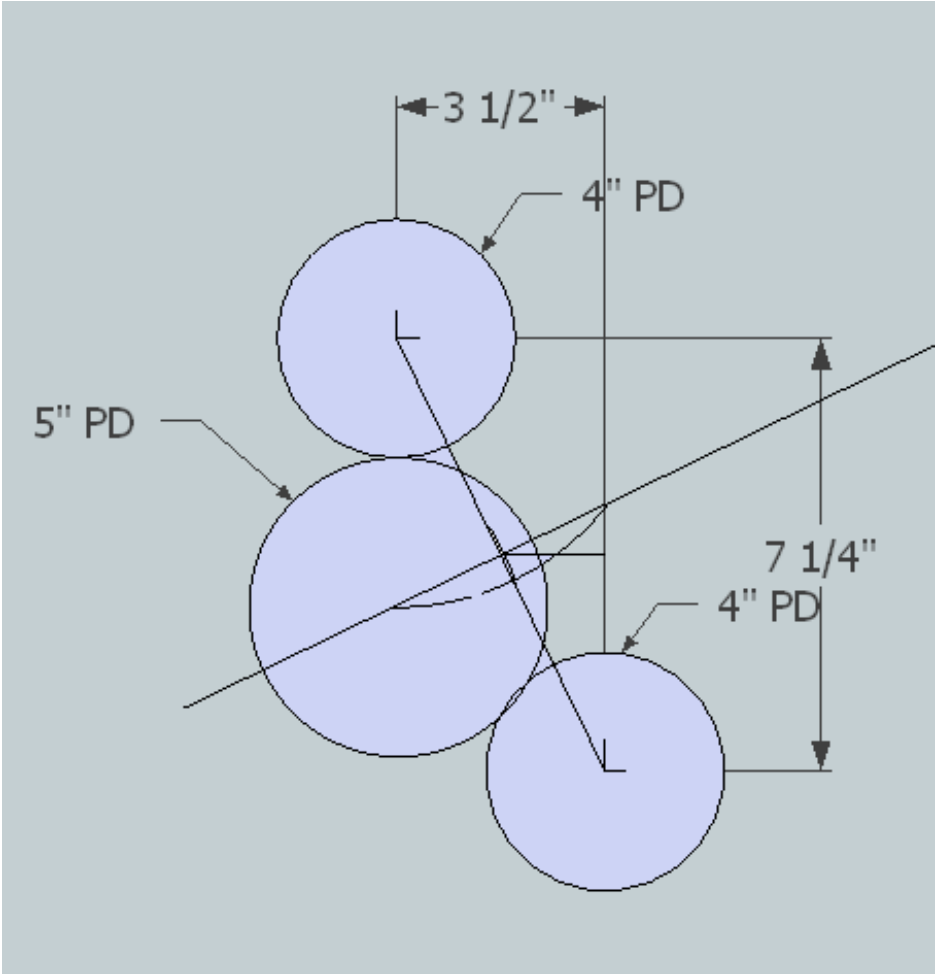
4. I think the bigger the gear teeth, the more forgiving the gear locations, and I need max forgivable for this design.

Layout #1



Four inch gears on the 2 shafts, and an offset 6” gear to connect them.

Another Option



Instead of a 6” PD gear, this layout uses a 5” PD gear. I think it will still give enough adjustment to get a good mesh and it is a smaller gear to make.

Diametral Pitch

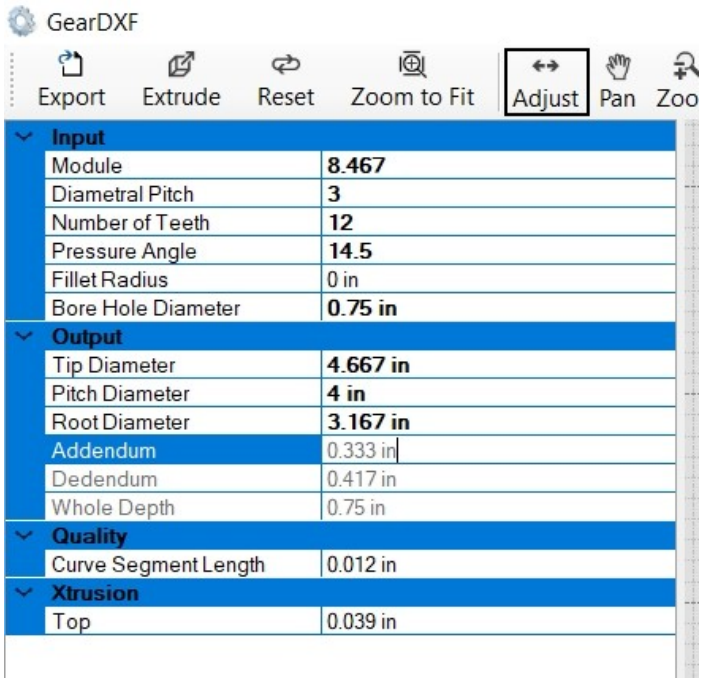
This is defined as the number of teeth divided by the pitch diameter.

For 2 spur of different pitch diameters to mesh correctly, the Diametral pitch must be the same.

As the Diametral pitch gets smaller, the size of the teeth get bigger and will allow more error for gear teeth run-out to their center.

On the 3 big gear marble lifter I made, it has nice big teeth.

The Specs I used to make this spur gear were:



Note: The diametral pitch was 3 on this one (12 teeth divided by pitch diameter of 4 inches = 3).

I think I should go with a diametral pitch of 3 on all the gears on this model, to give nice big teeth.

Gears for this Model

So the 2 gears on the 2 square driveshafts will use the same inputs as shown in the table above.

For the larger middle gear, we are going with a 5” PD as shown above, and we need to keep the diametral pitch of 3.0.

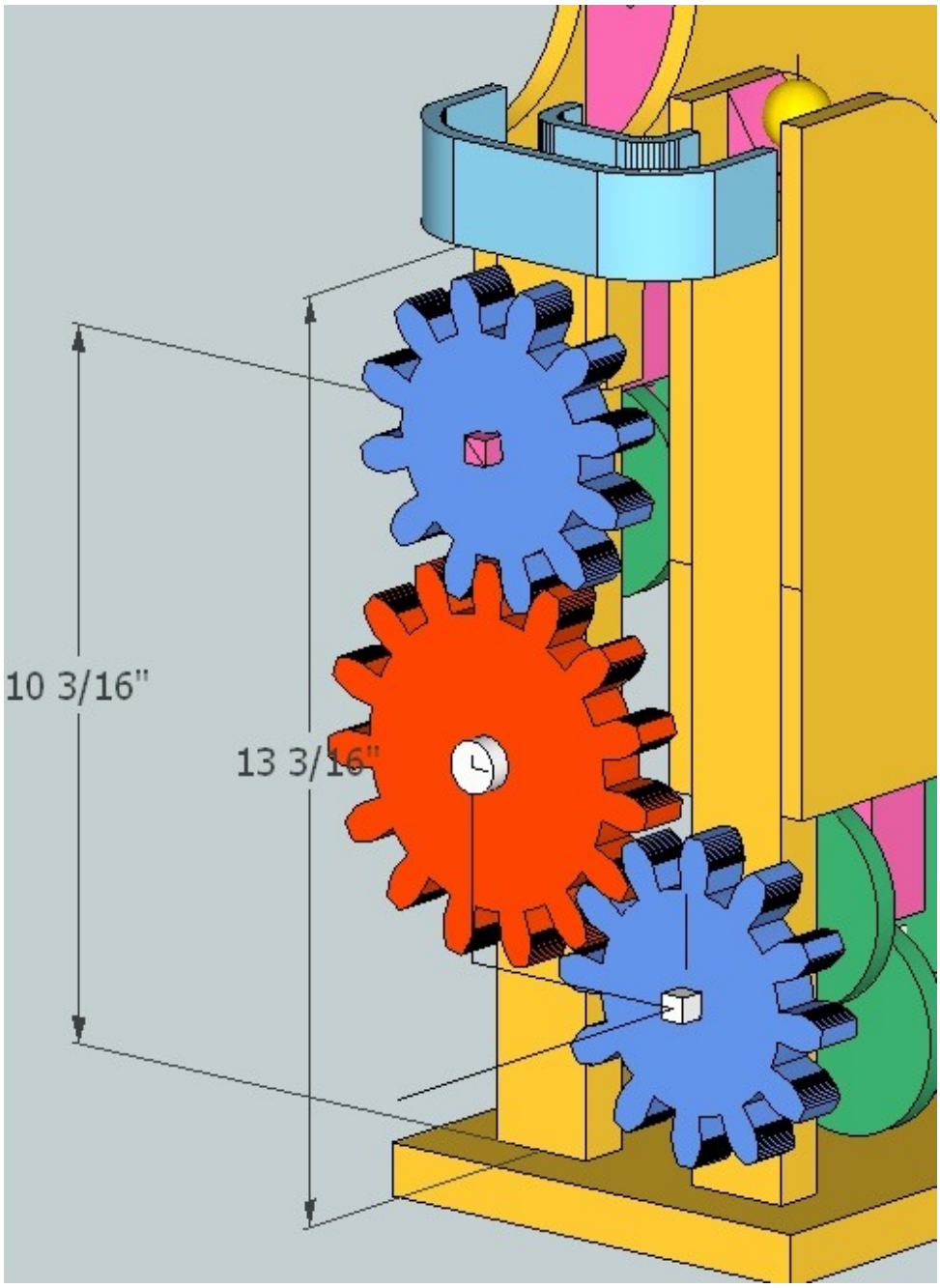
So # teeth/PD = 3…….PD=5…….so #teeth = 3 * 5 = 15.

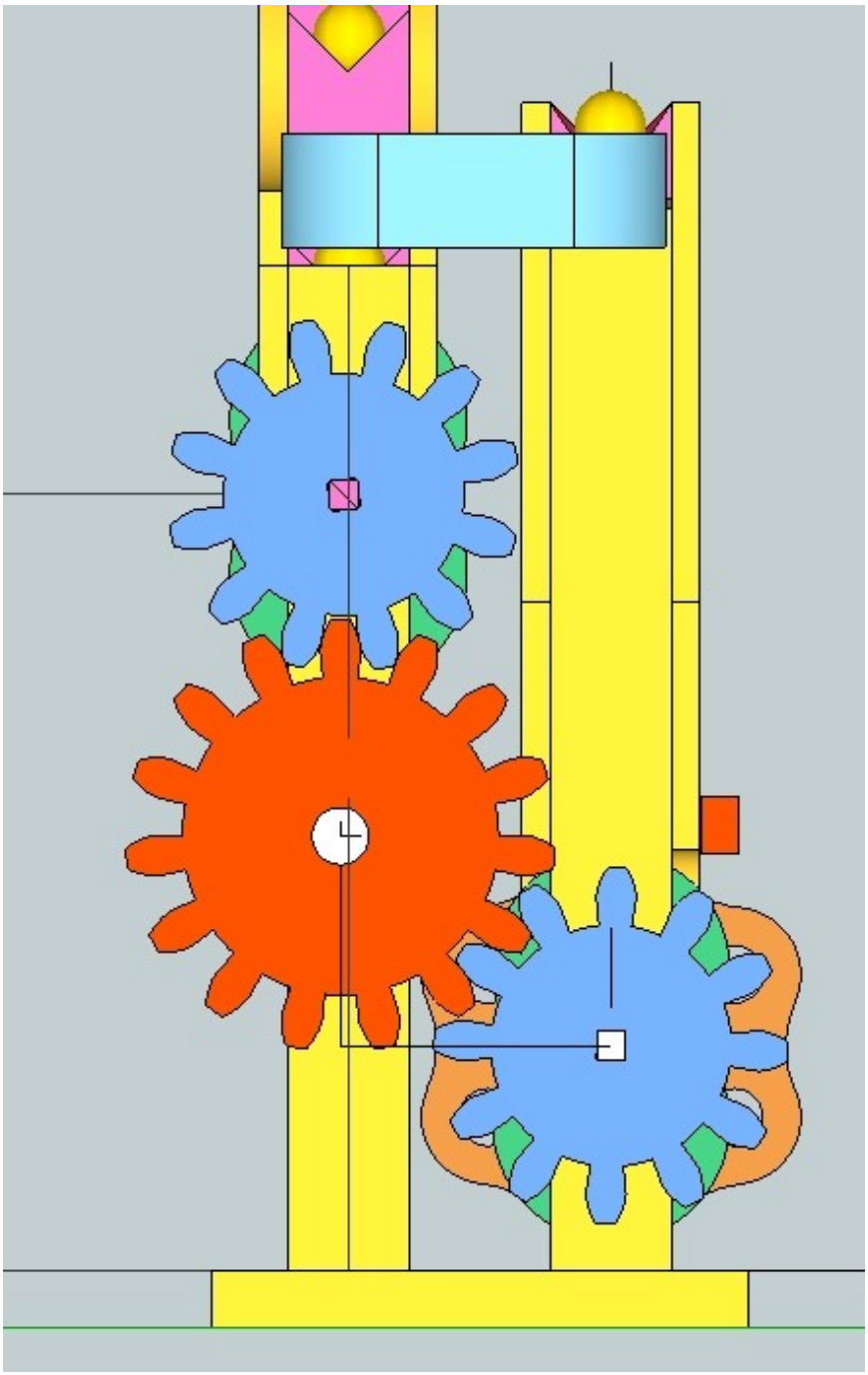
GearDXF.exe Free Program

I use this program to design my spur gears. You can download a copy free from the Internet.

I output a DXF file and then import it into Sketchup, to print out full scale drawings to make the gears on either the band saw or scroll saw.

Initial Gear Design in Sketchup





The ¾” round shaft for the middle gear can mount in the LH vertical support column, so I don’t have to add any addition support structure!!

OOOPS

I forgot to move the 2 vertical legs for the upper lifter assembly over ¾” in Sketchup like I did on the actual model.

When I moved it over, I found out the shaft for the center gear was only halfway on the vertical post, so I had to redesign it in that area.

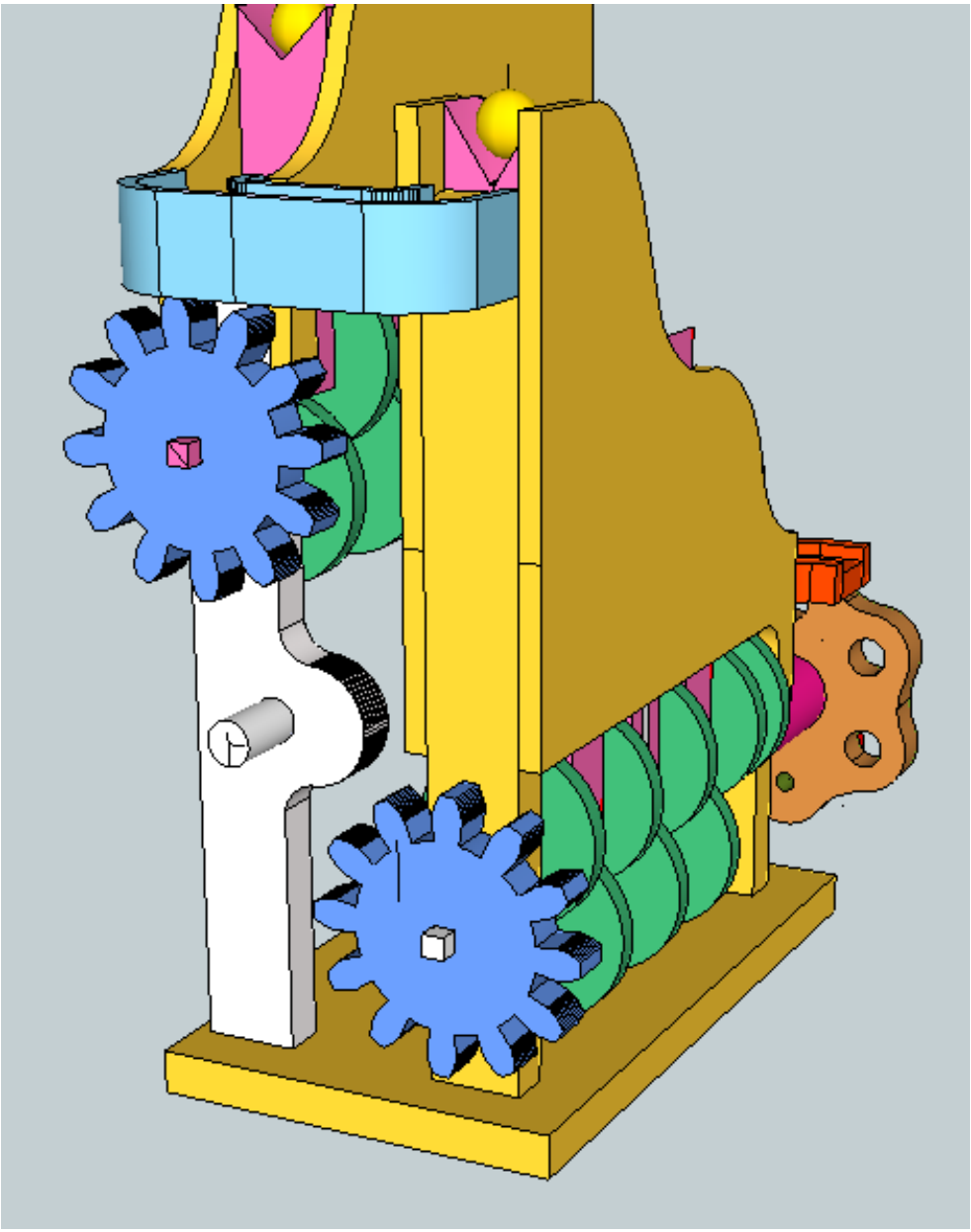
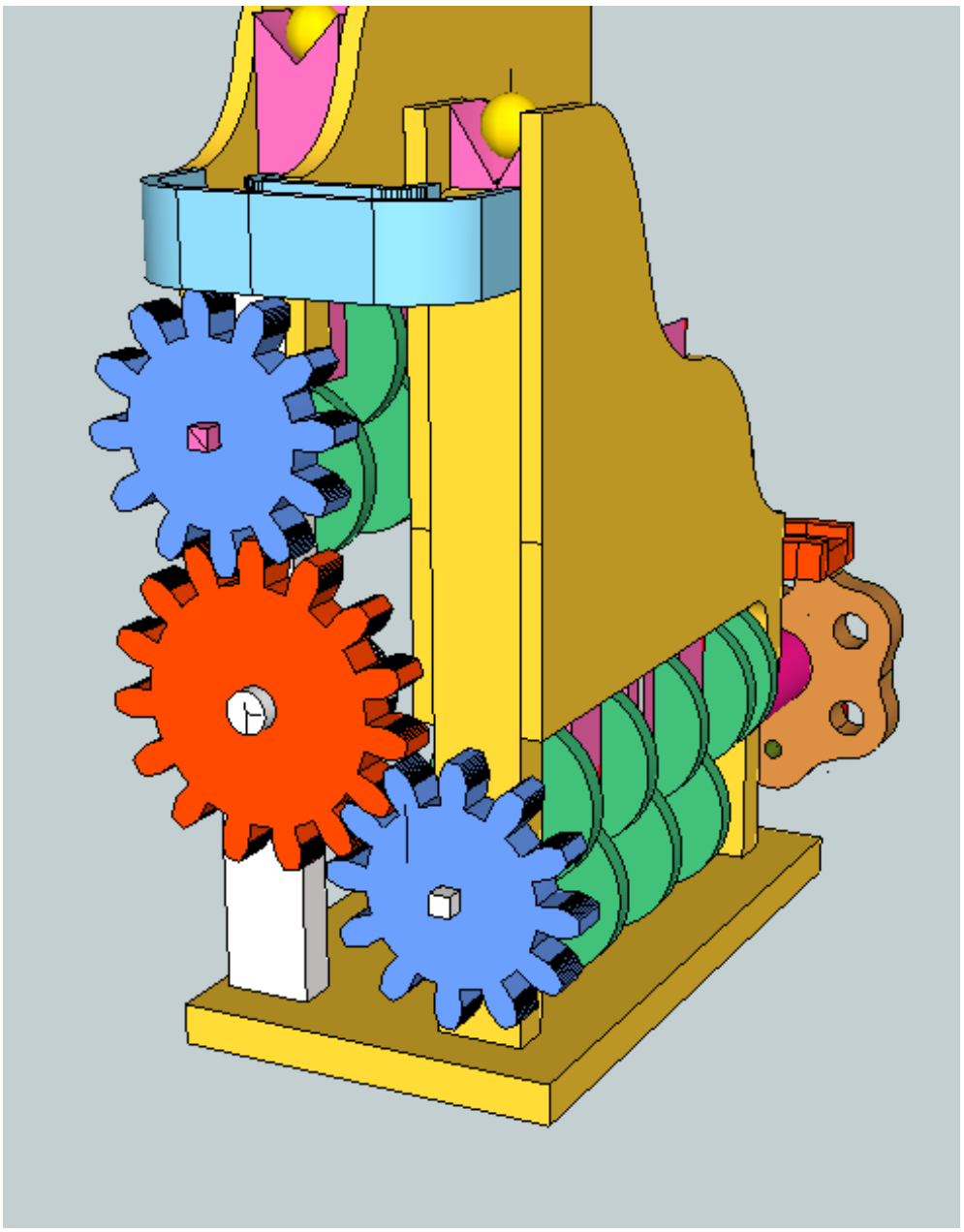


Photo above shows new vertical post with hump for mounting gear. Also theoretical center for middle gear.



Spacer between 2 Lift Assemblies

I screwed on a spacer which maintains the distance between the 2 lift assemblies. Without the spacer, both assemblies tend to wobble.

Cutting Spur Gears

Made them ¾” thick red oak, my standard wood for all gears. Band sawed the edges and then used the scroll saw to saw out the root of each tooth.

Remade Double Bend Chute

Since I moved 1 leg out ¾”, the 1st chute I made no longer worked.

Idea for Figuring Out best Center for middle gear

I could hot melt glue a stub ¾" shaft onto the vertical riser and try out the mesh. If not right, take apart and removed hot melt, and try again. When right, mark where to drill the ¾" axle hole.

Only Challenge Left (that I know of)

This will be locating the middle gear correctly, then see if the crank will run both units OK.

Sanity Check

I measured the center d*i*stance on the model of the 2 square drive shafts and got 8-3/8", which matches the Sketchup dimension. I just wanted to verify this, since I had to move the upper lifter assembly out by ¾" to clear the cams. If Sketchup was way off from the physical model, then my new vertical support with the bump for the middle gear would not be right.

Options for the Descending Marbles

1. Circular staircase
2. Bucket which lowers and releases
3. Bowl with bell
4. Divider(s)
5. etc

So Much for Hot Melt Glue Gun Idea !

Last time I used it, I forgot and left it on for 24 hours and cooked it.

It heated up, but would not discharge any glue.

Took apart, no obvious way to fix it.

Have to get another new one.

Tried 2 sided carpet tape to hold a ¾" dowel in place, but did not work

C-C Clamp Idea worked

Move gear until visually it seemed to mesh OK with both other gears. Draw pencil circle where dowel should go on vertical board.

Clamp in place with plastic squeeze clamp.

Use deep C-clamp to hold in place and try out.

I will make a video of it working OK with the lifters in place.

I finished the video.

Photos at this stage on 01-11-2024

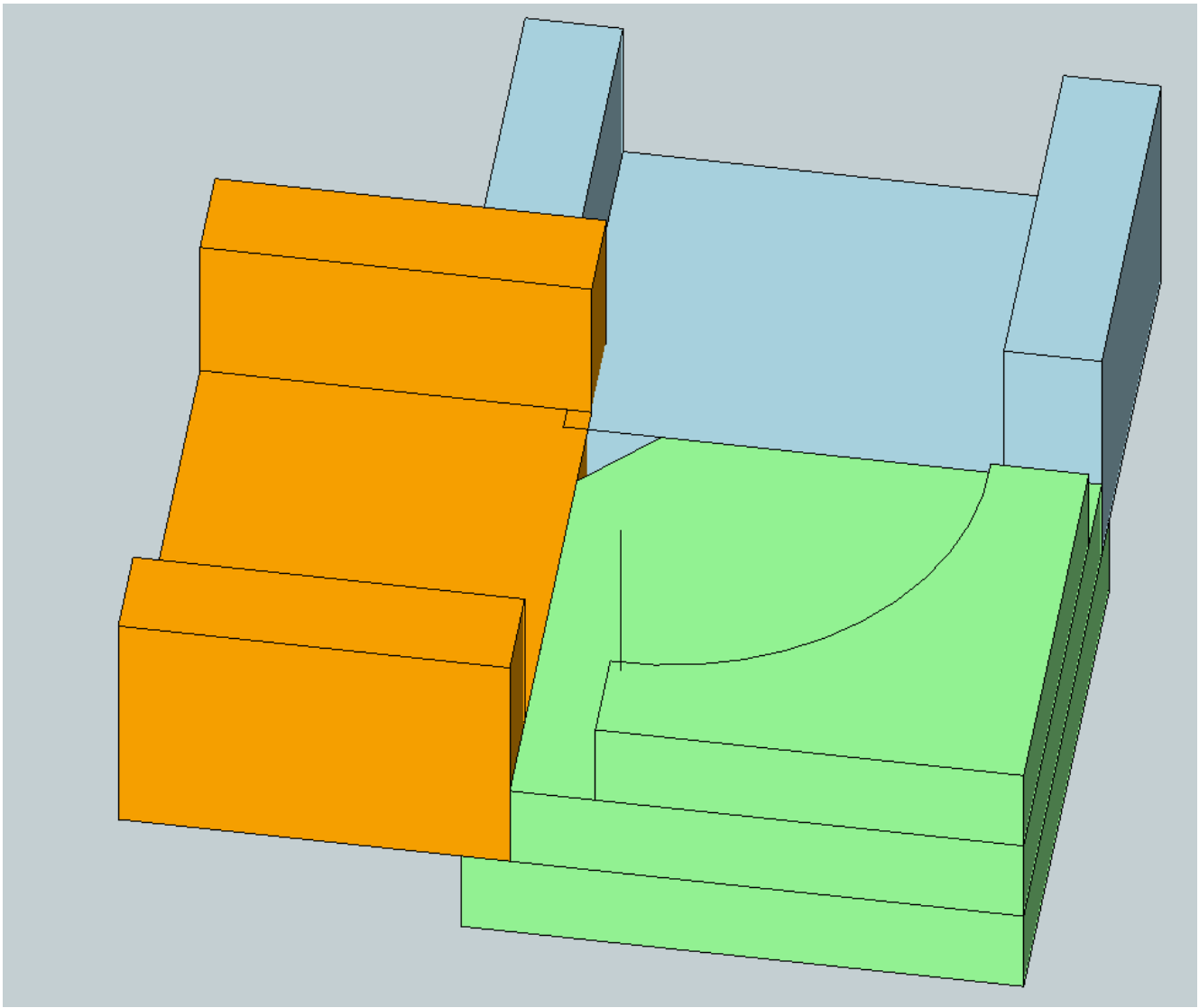
I drilled holes in the gears to “spiff” up the look of the model :)

Dividers

I'm going to use 2 of them, maybe even 3……..so I made 3 of them today. I simplified the design a little bit also, and used the new design in my Sketchup model of this new model.

90 and 180 degree Chutes

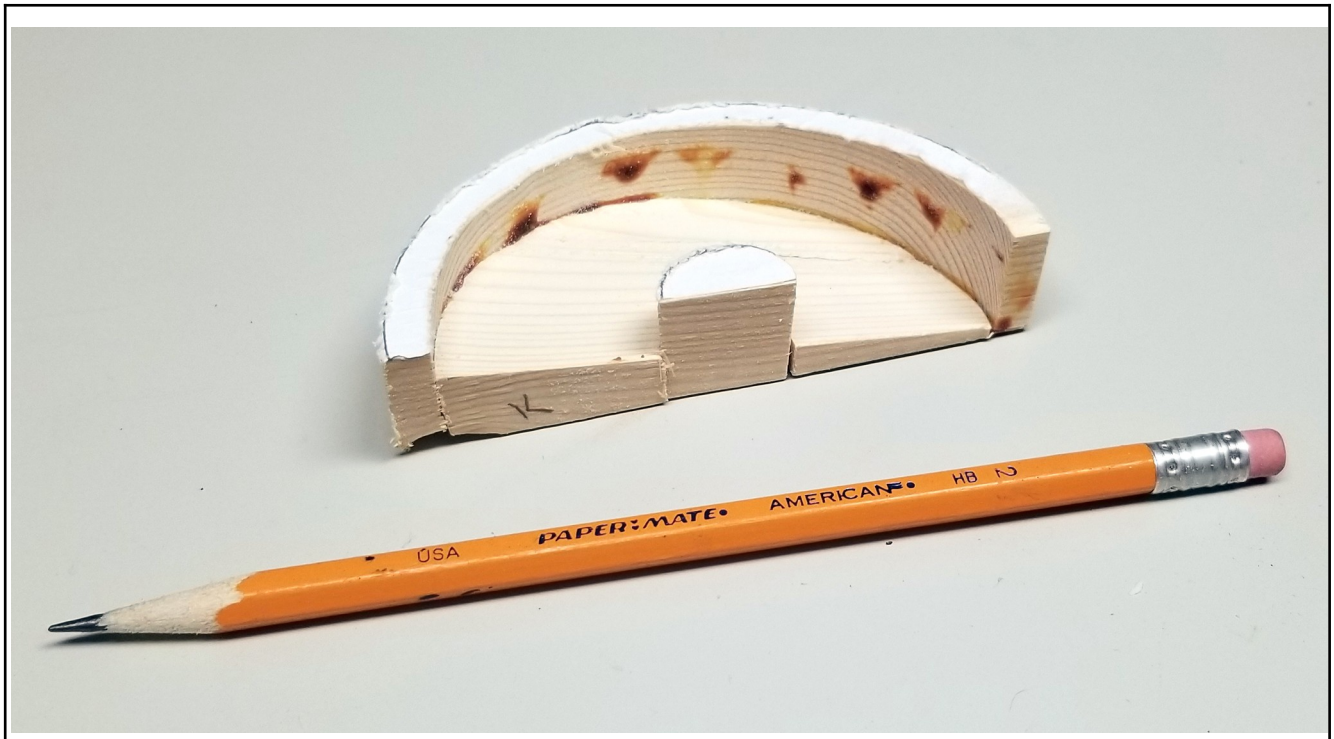
On past projects, I used the method the deceased Engineer used to build his huge marble machine.



Although these 90 degree bends work OK, it requires making 3 different pieces and then gluing them up. They mate with the standard chute that I use.

Standard chute sides are ¼ by 11/16” high with bottom being ¼ by 1-1/8” wide.

I have been experimenting on reason projects, and I like scroll or band sawing out the pieces from either ¾” thick or 1.5” thick standard pine. I cut the slope in the bottom using a handsaw or handsaw.

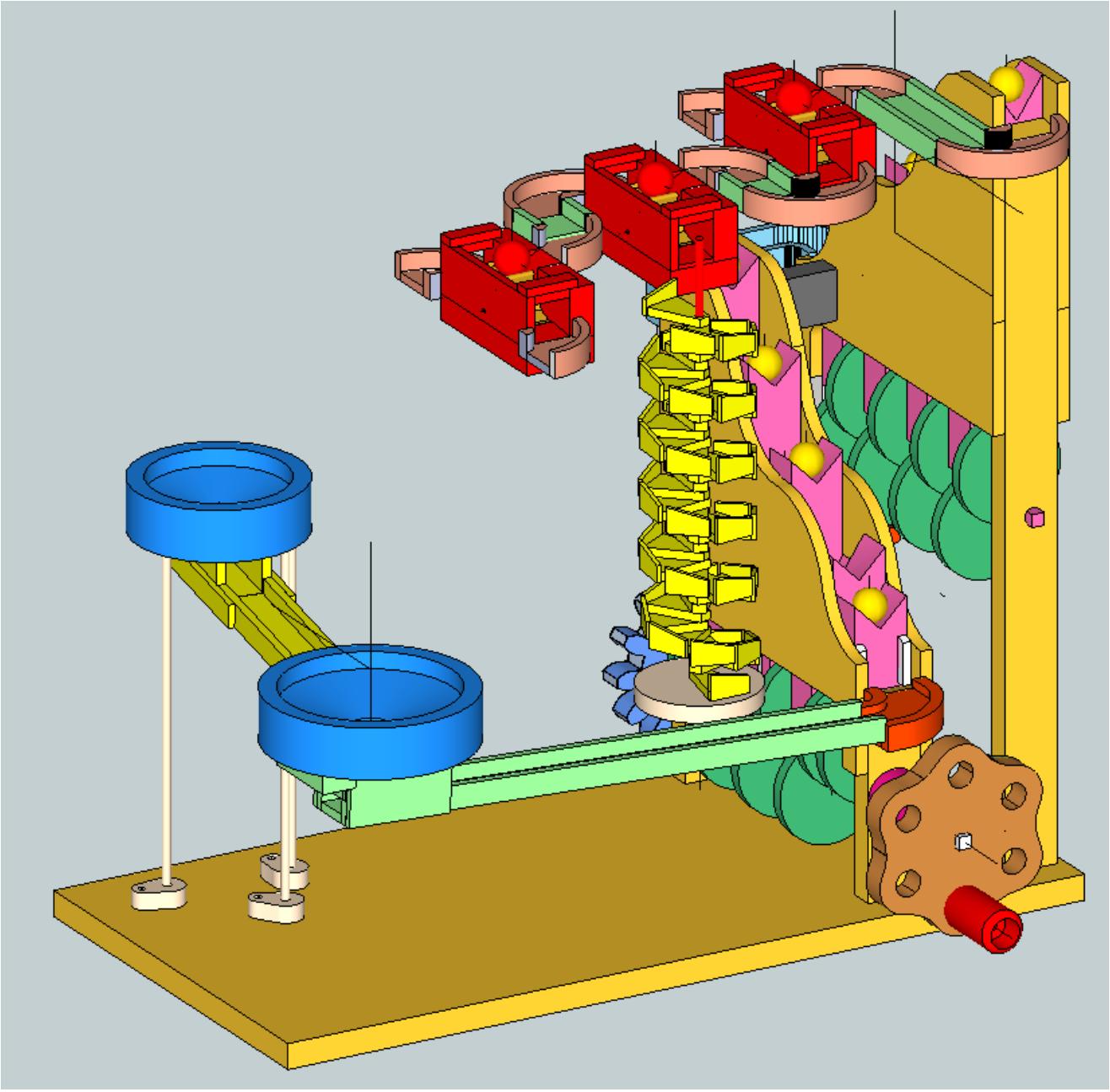


90 degree bend from standard 3/4" thick Pine.

How do the marbles make their way back to the return?

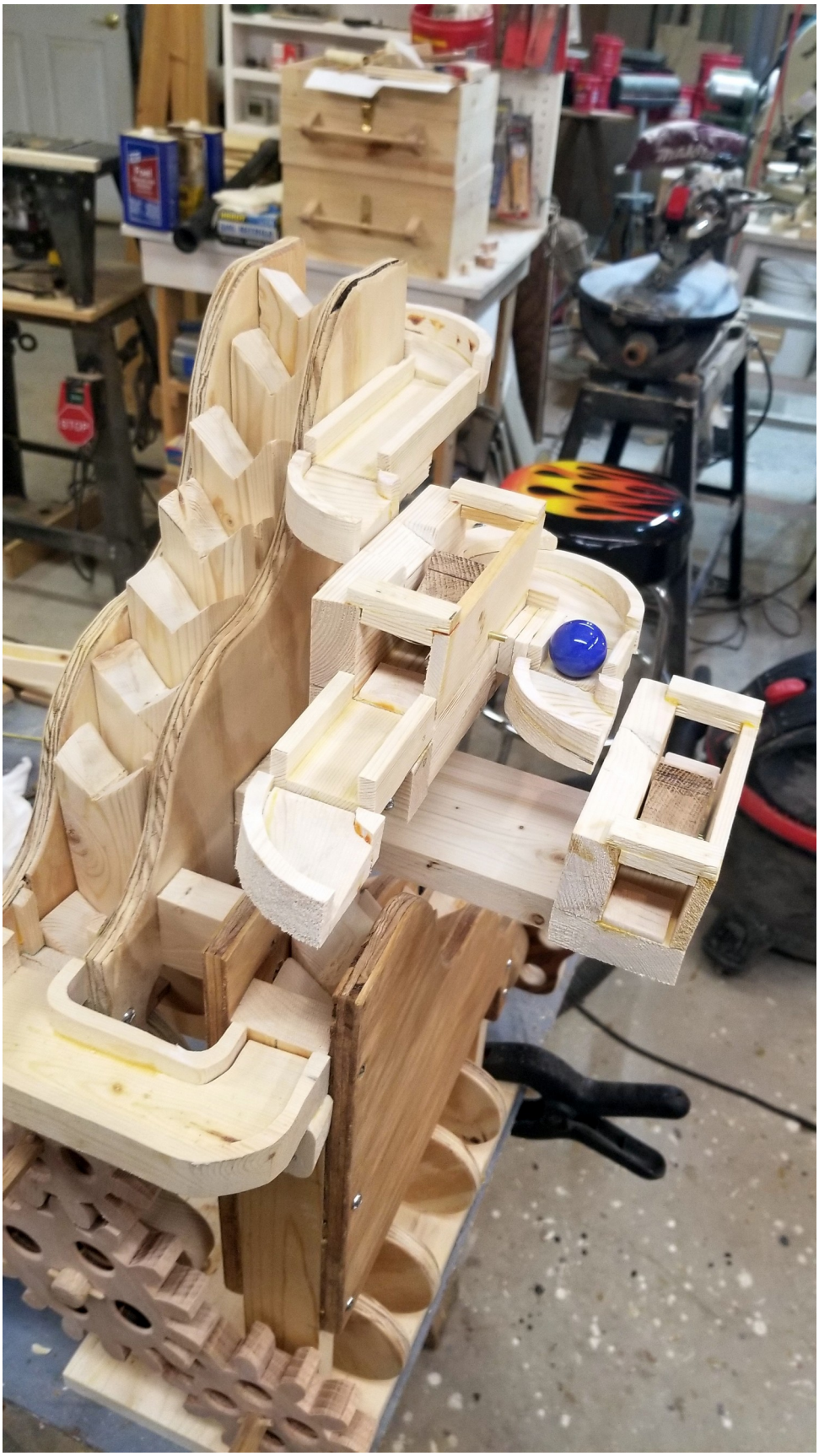
I started to layout how I want the marbles to return in this concept.

I am concerned with the round staircase exiting onto the entry chute if there are other marbles in line waiting to feed in?



Condition of the Model on January 17, 2024

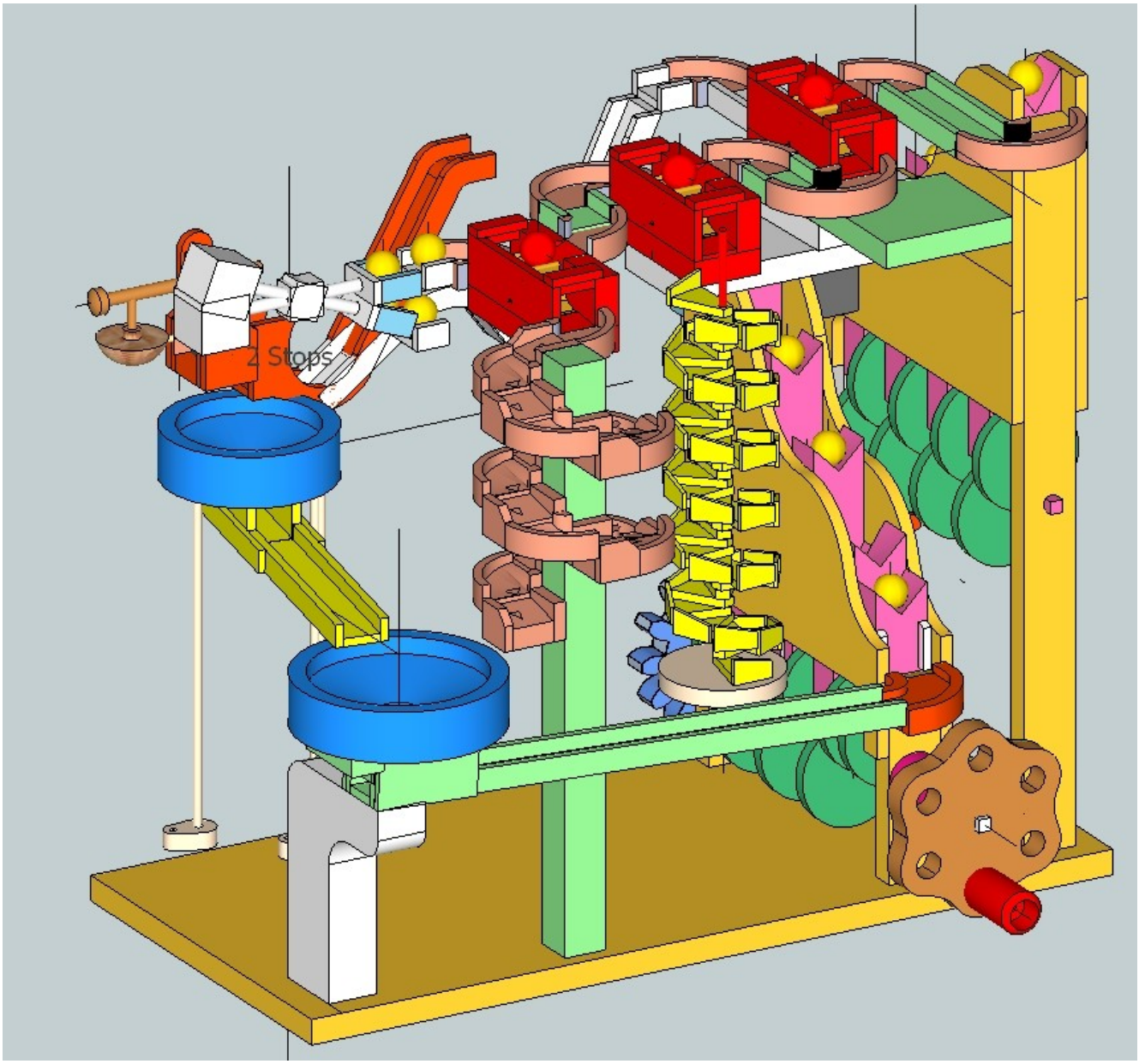
I started from the 2nd story cam lifter and added the 1st and 2nd switcher boxes, using the small base piece, because I don't need to go to the large base yet.



4 Ways for marbles to descend

I think I have figured out the 4 ways for the marbles to descend.

1. Down a curved path, hit a bell, go to round bowl.
2. Into a bucket that descends onto a ramp to a round bowl.
3. Circular staircase and into entry chute.
4. Kind of a circular staircase and into a bowl.



Time to Transfer Mechanism from small to large Base Plate

One dilemma was how do I mark the holes in the large base with the screw holes already in the 4 legs?

I ended up marking where the screw holes were, onto the side of the legs, then transferred those marks to the base board. Worked great !!

Bound Up

After I transferred the mechanism to the large base plate, I tried cranking and it was bound up.

Found the middle gear was rubbing on its shaft too much. Took the Dremel with ½” drum sander and reduced the OD of the shaft, then the whole mechanism worked fine !!

Mechanism transferred to large base plate

Making first Bowl – 6” OD

1. cut blank from 2 by 8 pine
2. draw 2 diagonal lines from the corners to find center
3. mark center with awl
4. using compass, draw 6” OD and 5” ID for a ½” wide rim on outside
5. drill through with small drill bit
6. draw 6” OD with compass on side with no circles
7. drill pilot for lathe face plate, the smaller 3” OD one
8. holding face plate in vise, screw down the blank
9. leaving small face plate on, and up, handsaw about 1/8” bigger than pencil 6” OD
10. turn OD on lathe
11. turn ½” wide outer lip and angle to center. Quit when see the tip of the wood screw in the face plate.
12. remove face plate
13. drill 1-1/16” diameter hole in center (can be 1-1/8 or 1-1/4), I have special 1-1/16” bit for marble games
14. chuck on OD in the lathe and turn center thinner, leaving about 3/8” of wood
15. bowl is complete except for sanding and painting

Status January 18, 2024

Had a good day. Made both bowls on the lathe. Got 1st bowl mounted with long track. Just about ready to mount 2nd bowl.

Mounting the bowls first, then getting their “as-built” measurements on the model, will help me better design the gizmo’s that must connect to the bowls.

Houston – We have a Minor Problem

Once I got the front, LH side bowl installed and I could estimate where the back feeder bowl would be mounted, I took the following “as-built” measurements from the wood model and entered them into the Sketchup design.

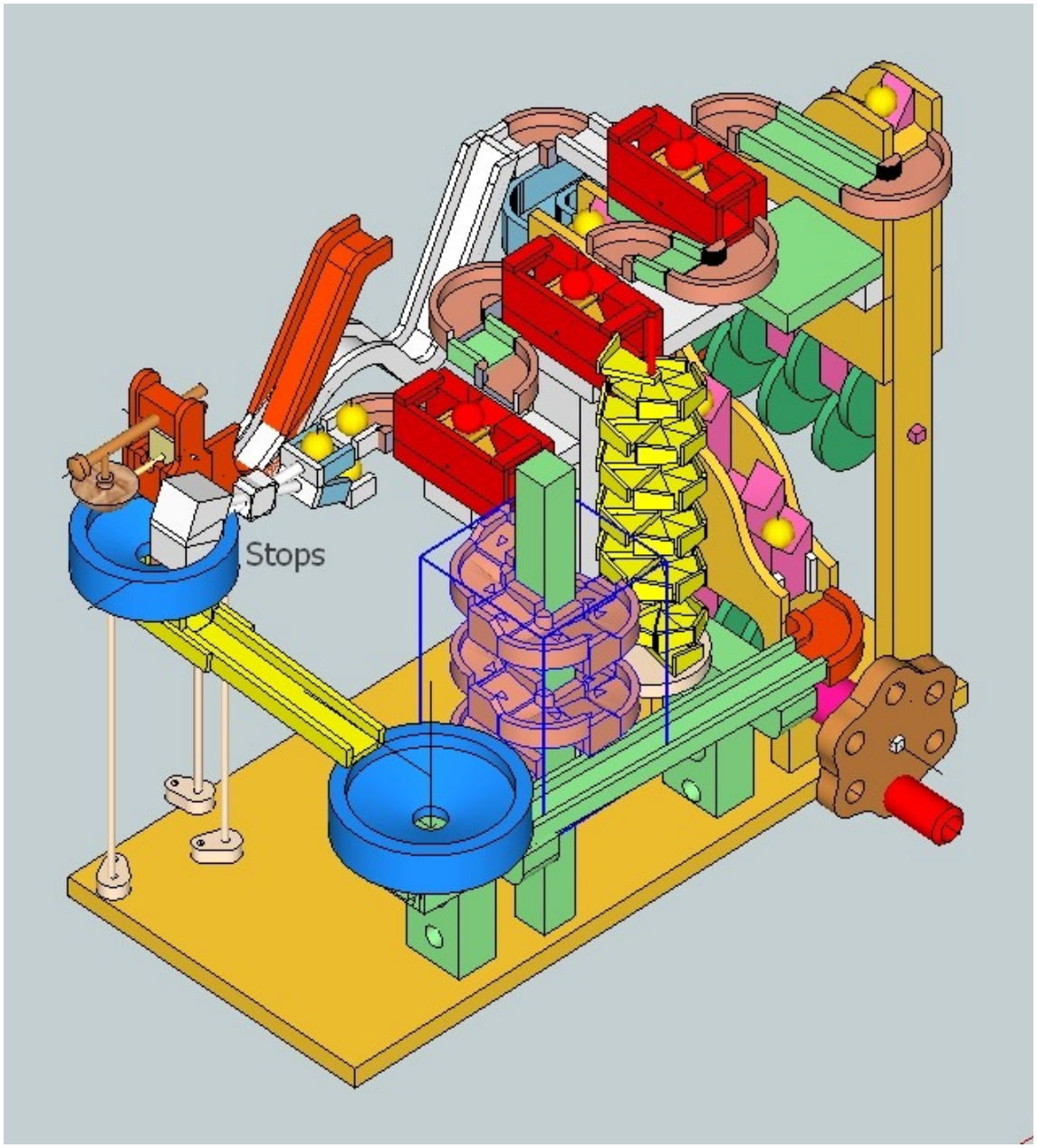
Top switcher	to top	20
Middle switcher		17.5

Lowest switcher	15
Top of front bowl	10.25
Top of back bowl	13

So of the 4 ways down for the marbles, 3 of them will still work (circular staircase, around a center pole, back deep curve to top bowl).

On the bucket that drops the marble, it is too low to enter the top bowl. I will have to rotate it about 45 degrees and have it empty into the lower bowl.

So, it was a good idea to check the as-built dimensions in the wood model before I design the 4 ways down in detail !!

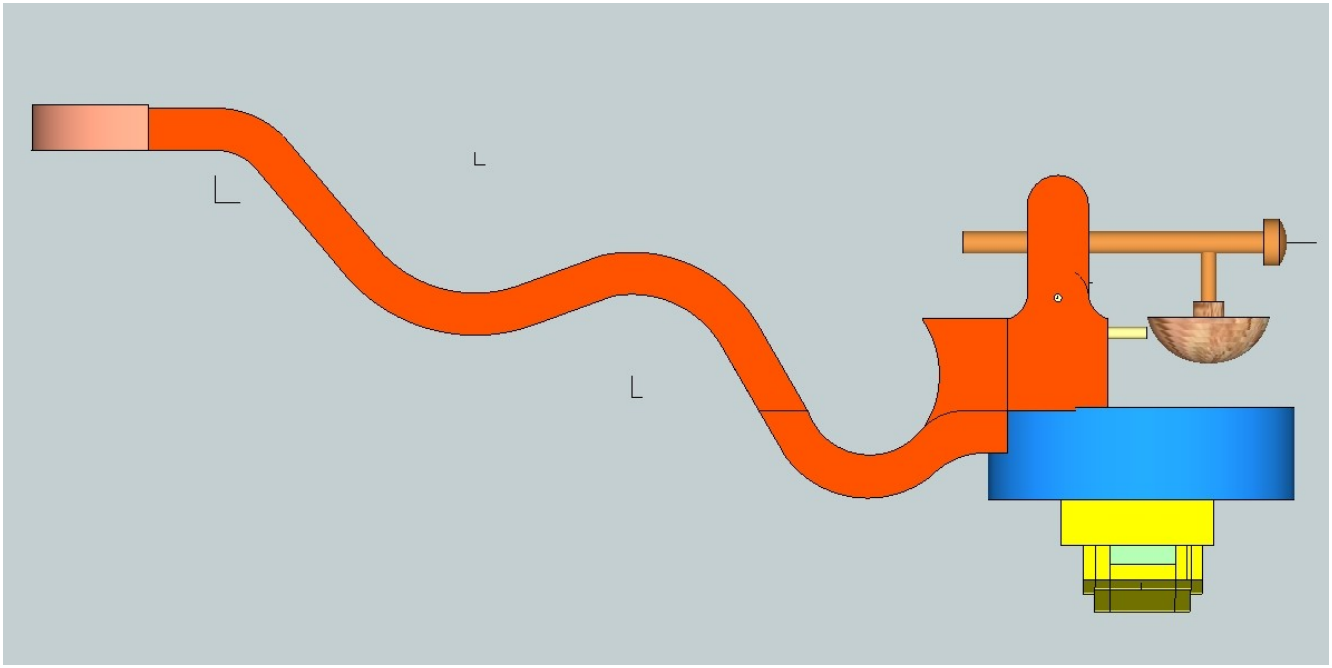

Stops

Houston – we do have a problem

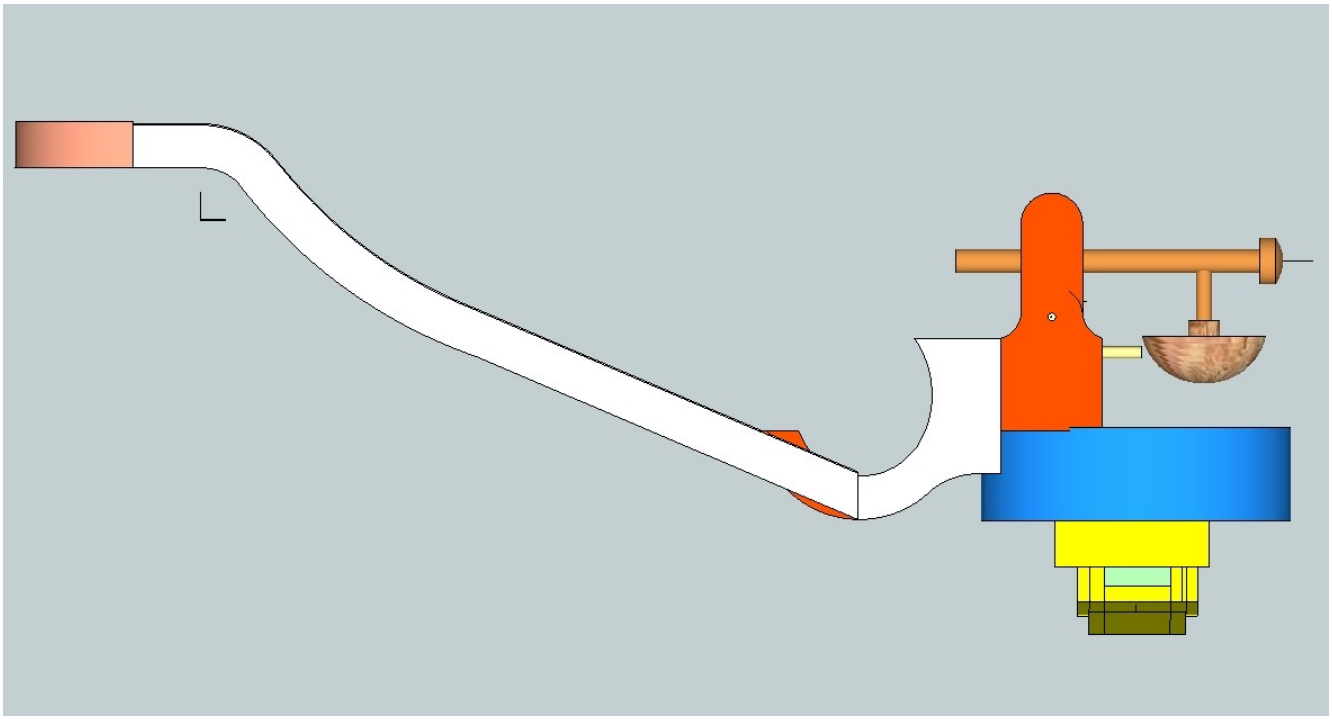
I planed down a piece of 2 by 8 to make the 1-1/16 wide back curved track. I band sawed the top off and decided to test it in the vise.

My middle hump is way too steep and the marble either flies off or falls and stops at the bottom. Guess I will have to smooth out the curve !!

Bad curve is below.



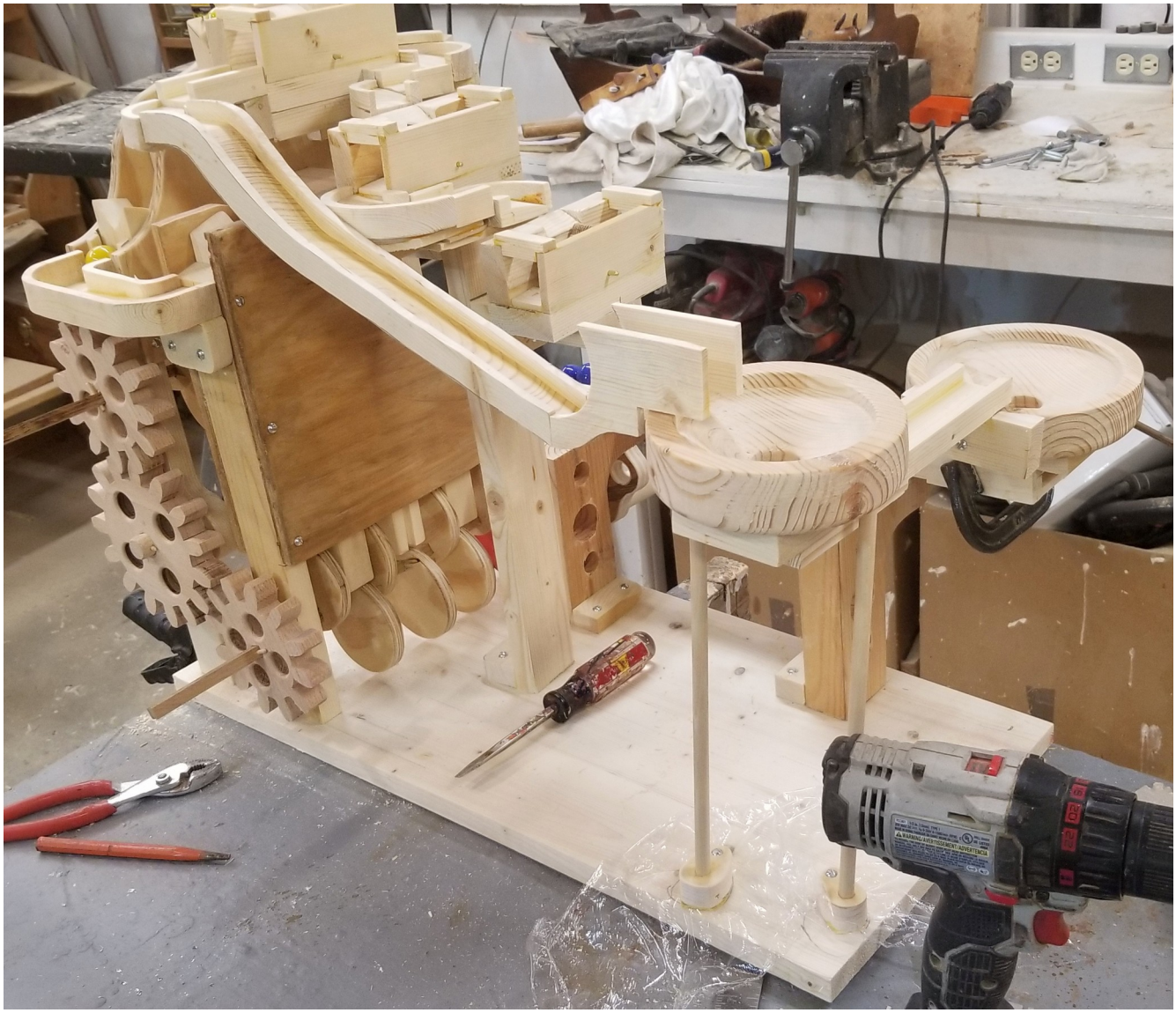
Less steep curve:



End of Day January 19, 2024

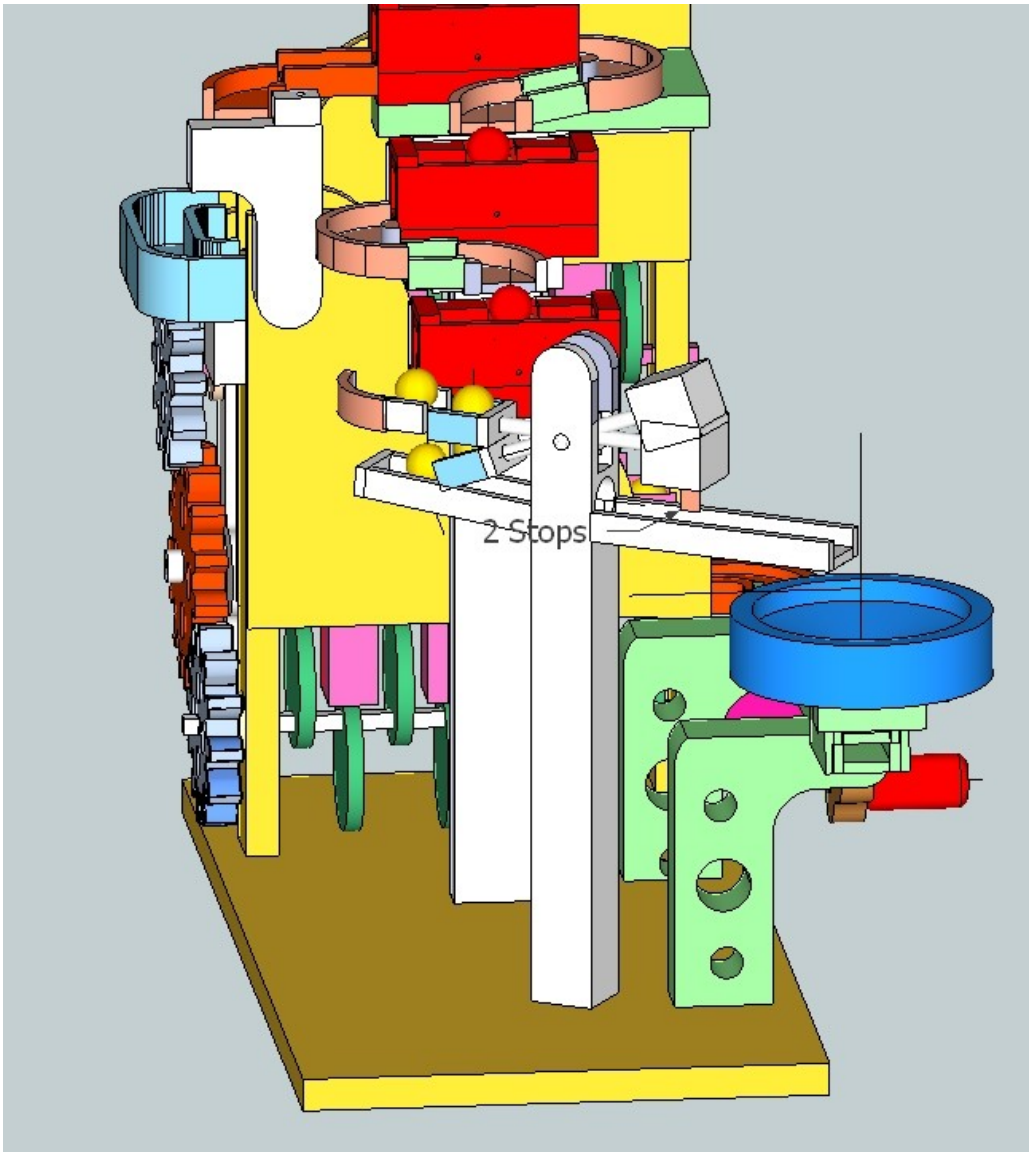
Pretty good day. Lost couple of hours re-designing the back curve because the original design was too steep and launched the marble.

Ready to attach the back curve, and add details at end for ringing the bell.



Design for Bobbing Bucket Feature

Using the initial concept, I came up with a detailed design, to build the 1st attempt at this new feature. I ended up having the marble go thru the central support column, which is sort of cool :) I'm sure there will be some trial & error debug on this new feature!

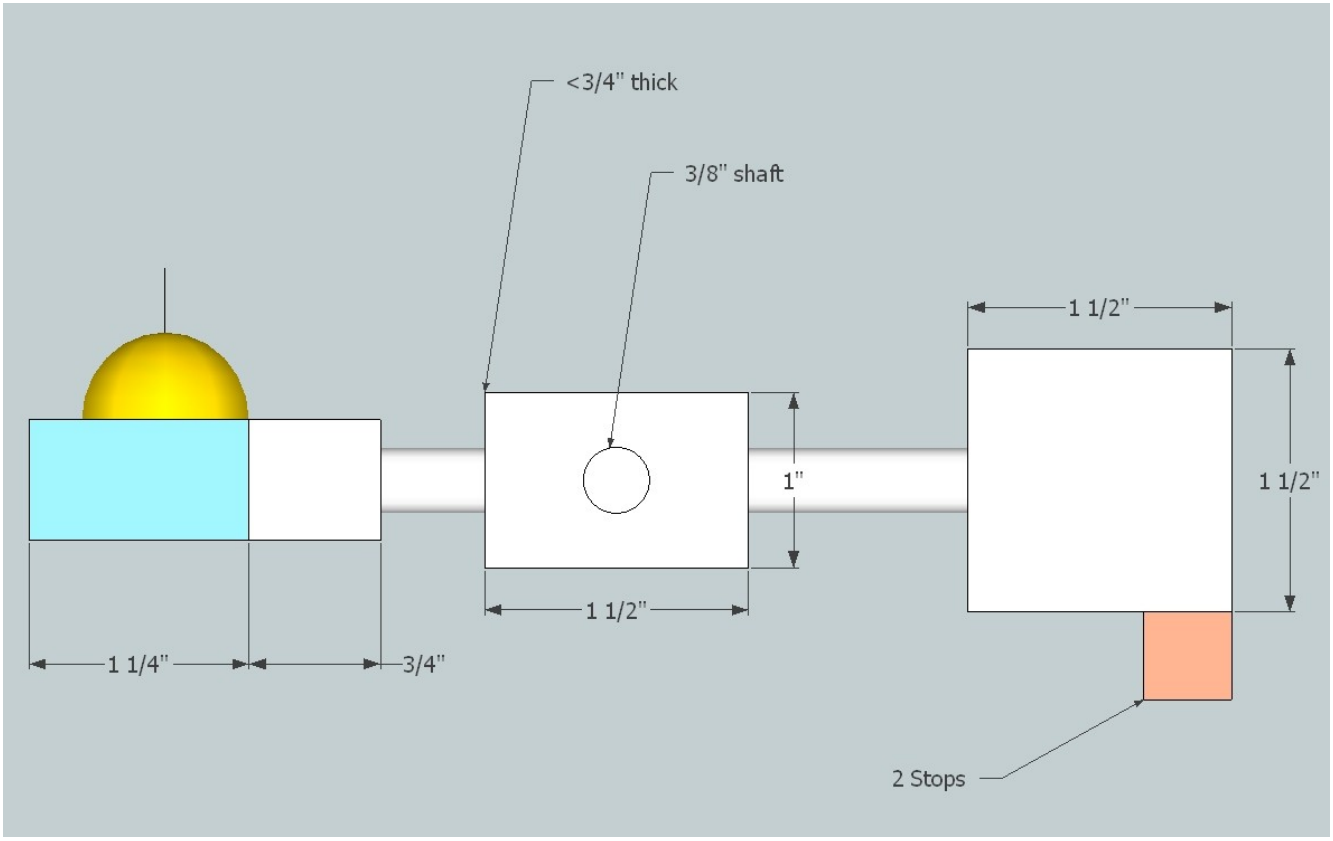


Week-end of January 20th

Did not work on the model a lot, had grandchildren stuff to do.

Got the 1st attempt at the dunking tower built. Was nervous the bucket discharged the marble too low, and I would not have enough elevation to make it to the lower bowl……...but it tentatively works just fine, shewwww !!

Beefed Up Design for Bucket



OOOPS

When I went to glue up the bucket assembly shown above, I had the bucket rotated the wrong ways 90 degrees, DARN !! Sawed off the 3/8” dowel, re-drilled both pieces and glued back together the correct way. Murphy of Murphy’s Law is alive and well in 2024 !

Bucket Assembly Installed and Working

Starting to build the tower that marbles go around in the Vise

End of Day January 22, 2024

Was a good day. 2 of the 4 ways the marble travel down are finished. The 3rd, the tower will elbows is started, leaving the circular staircase for last.

1st Tower is Completed

Although 1” marbles worked OK just on the tower, when I hooked it up to the switch boxes, sometimes there was enough speed for the marbles to shoot out of an elbow or straight section on the tower!!

So I can add some height to some critical elbows or straight sections. Or add a bell at the beginning to slow down the marble as it goes down the tower.

I will probably also have to do some adjustment for how the marbles enter the entry ramp also, will do that later.

Sketchup for Tower Elbows

I went into Sketchup and made the inner track sloped, just like how I band sawed them to make them. Might make future YouTube video about this.

Circular Staircase

Started with marbles descending in a CCW direction as viewed from the top, which was the design or the Big Marble machine I built a couple years ago.

I made 6 steps and tried it out. It makes more sense to change to a CW direction, to better fit in the model and discharge further up in the entry chute, so I am switching directions.

Minor Problem with Circular Staircase

I was disappointed to find marbles did not follow the path down, they shot out of the steps!!

I don’t remember this issue when I built the marble machine several years ago.

I went back to the big marble machine, and I used 3/16” thick for the step bottoms. I used ¼” thick for the new model, so the outer walls are 1/8” shorter on the new model. On the top steps of the old model, a few of the walls are 1 tall versus ¾” I used for this model.

So I guess I will hot melt glue on some ¼” taller walls on my new model, which should solve the problem. I need to update my new SketchUp model to reflect this.

Minor Problem with Heavier Duty circular steps

I added ¼” high curved piece to all curves, and this stopped marbles from leaving the steps.

I tried to make these elbows from standard ¾” thick pine, so if I stayed with this plan, I would add the ¼” strips cut from ¼” thick pine to get enough height.

Model is Done January 24, 2023 – Time to Gussy it Up Some

I added a wood male person on the tipping bucket.

Added a bunch of wood balls to dress it up, and shown in this photo.

1 person (male) and 8 balls, makes it look nicer :)

Taking Her Apart

Got it all apart or sanding and painting.

Left 2 lifter assemblies functional so I could try to reduce torque required to turn the handle.

Drilled the lifters with ¾” Forstner bit sideways to reduce weight. Seemed to reduce torque some. Wish I had a way to measure torque to run the handle, but I don’t.

Might try drilling out each cam to reduce the rotating mass, since there is 16 cams.

I plan on following finish.

Cams……...red water stain, then polyurethane to reduce friction.

Lifters…….yellow water stain, then 3 rounds of sanding to 220 grit and poly.

2 sides……..oil stain dark brown then 3 rounds of sanding to 220 grit and poly.

On my small oak lifter assembly like this, my poly finish on it seems to have reduced the friction done to almost nothing, hoping for same thing here.

Rather than 220 grit sandpaper, I used my blue 220 grit sanding sponge blocks to sand the insides of the 2 vertical sides.

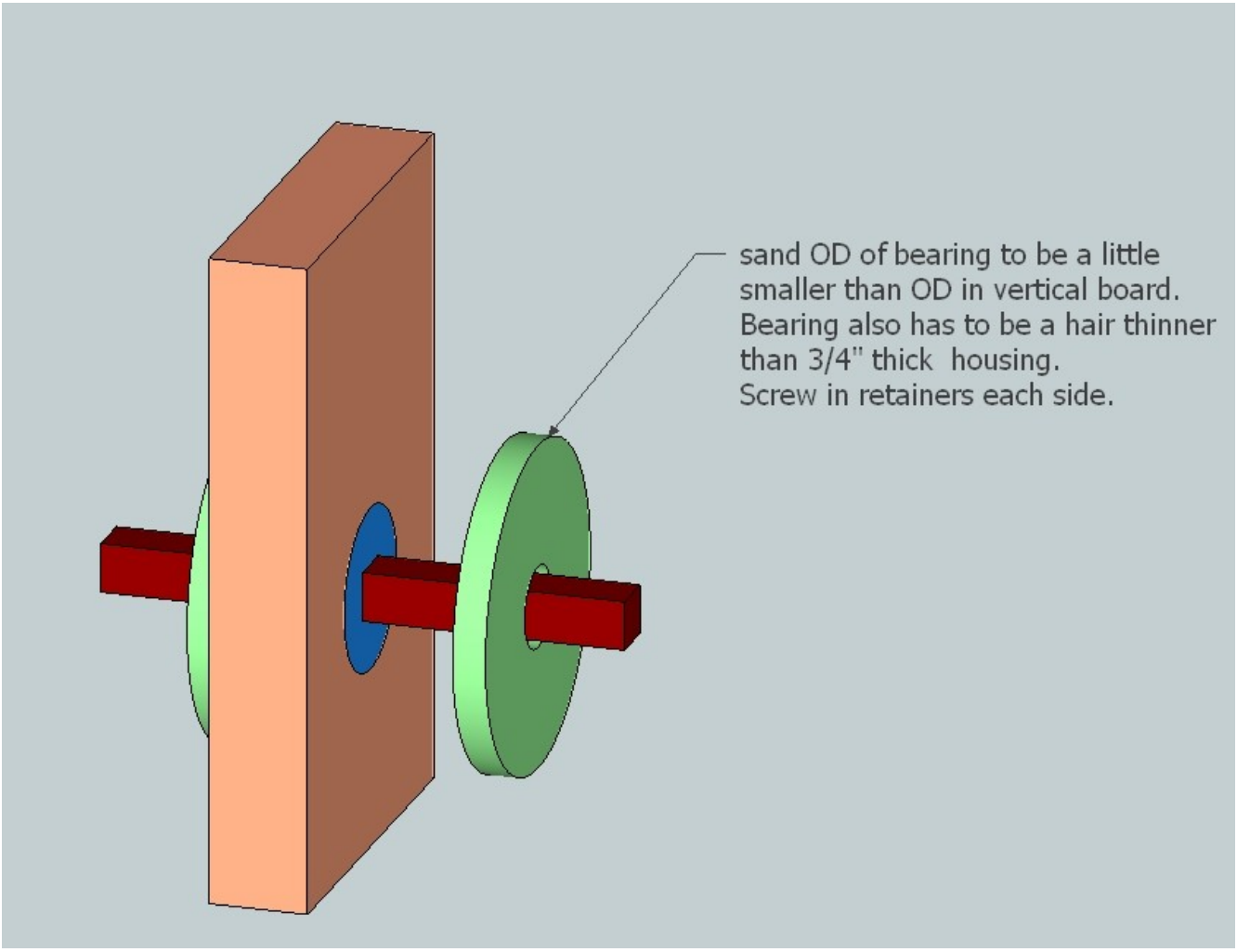
Do I need Bearings on the Crankshafts?

When I stripped down the model to just the 2 lifter assemblies with no lifters, there was hardly any friction as expected.

But when I put in the 16 lifters, I had a much higher level of friction requiring more torque to hand crank the unit. Even with all the weight drilled out of the lifters.

I wonder is the 3/8” square white oak shafts are “digging” into the vertical pine supports with ½” holes for the square shafts to turn in?? With no lifters, they would not dig in. But with the weight and friction of the lifters, this digging in might cause more torque to be required [I want to minimize the hand crank torque required to run the model].

To eliminate this digging in friction, I could make some wood bearings like this.


sand OD of bearing to be a little
smaller than OD in vertical board.
Bearing also has to be a hair thinner
than 3/4" thick housing.
Screw in retainers each side.

I guess I will try out the model after all the lifters and sides are varnished, and see how much friction I have before I decide whether to add the wood bearings.

WOW Close of Day January 27, 2024

The whole success of all my hand-cranked models is or the crank torque to not be too high, and model must handle 100 RPM on the crank, since kids can crank that fast for a short time period.

I was worried this model might not work because of too high of torque.

I did following process on vertical sidewalls……

-oil stain
-dry in oven
-poly coat 1
-sand to 150 grit (turns out my blue sponge type pad is 150 grit, not 220 grit)
-poly coat 2
-sand again
-poly coat 3

On the lifters:

-water dye color stain yellow
--dry in oven
-poly coat 1
-sand to 150 grit (turns out my blue sponge type pad is 150 grit, not 220 grit)
-poly coat 2

I did not do a 3rd sand and poly on the lifters, they were pretty smooth.

Assembled up with no lifters. Put Johnson's wax on crankshaft holes, and on 3/8 by 3/8" square crank where it rubs on the vertical supports. Put Johnson's wax on the lifters, including the bottom where the cams contact them.

With lower set of lifters installed, friction level or torque level was excellent :) :)

Can I Reduce Hand Crank Torque Required Even More?

Although the current torque level is probably OK, I would like to reduce it some more.

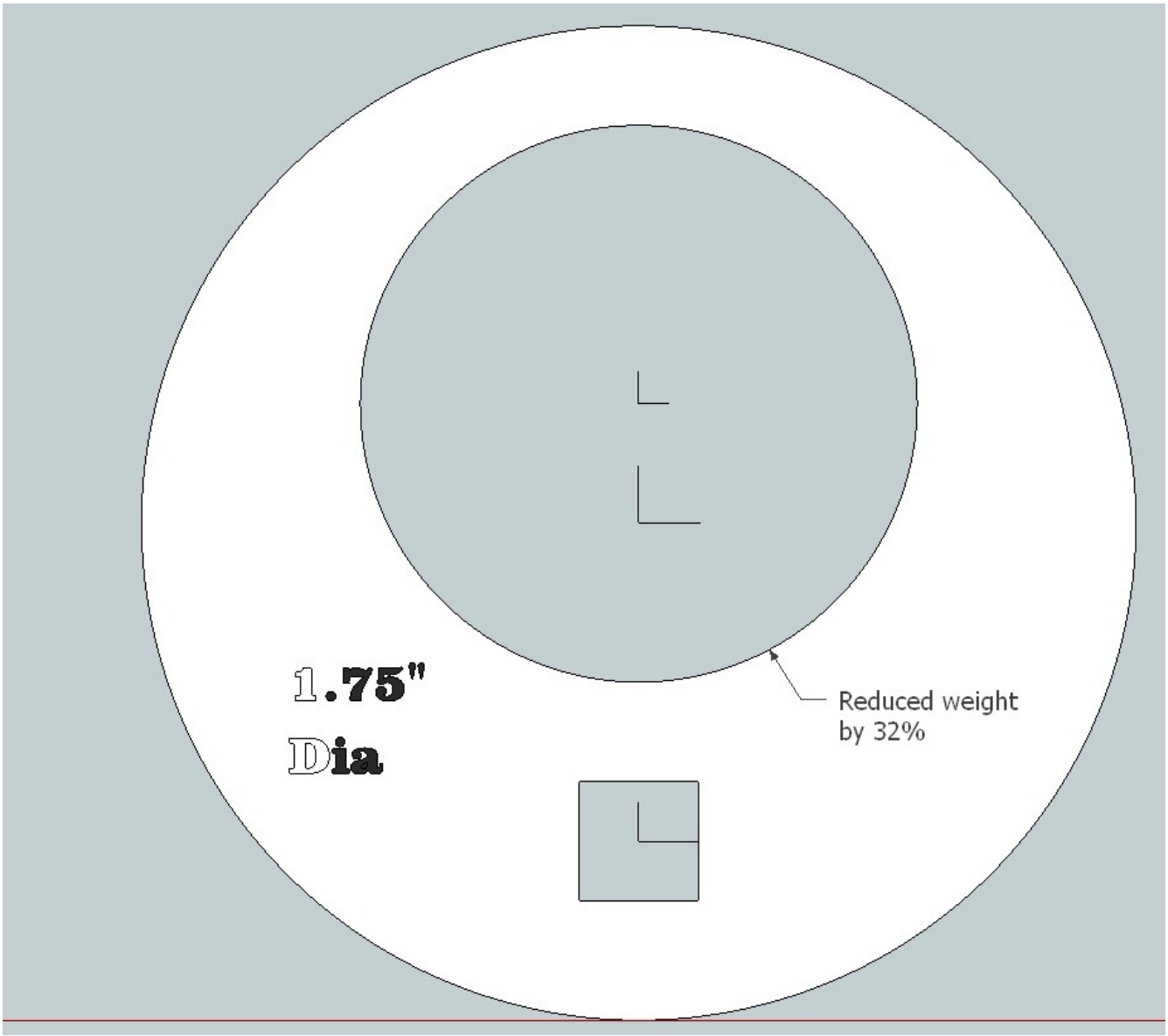
One option is to sand the OD's of the gear teeth to make engagement better. I watched the gear run, and they don't engage that much, so sanding the OD's will probably not reduce torque. If I had more teeth and a tighter mesh, it would make a big difference. There is no easy way to check the run-out of the OD of the teeth to the center since they are on a square shaft. I could use my standard method of a stub of ¾" diameter dowel in a plywood scrap on the drill press on the big gear, but since low engagement, won't do much good.

I checked run-out on big gear, and it was very good. Did nothing to it except sand teeth with 3/8" dowel with slit or sandpaper and applied stain, no poly. Did this to other 2 gears also.

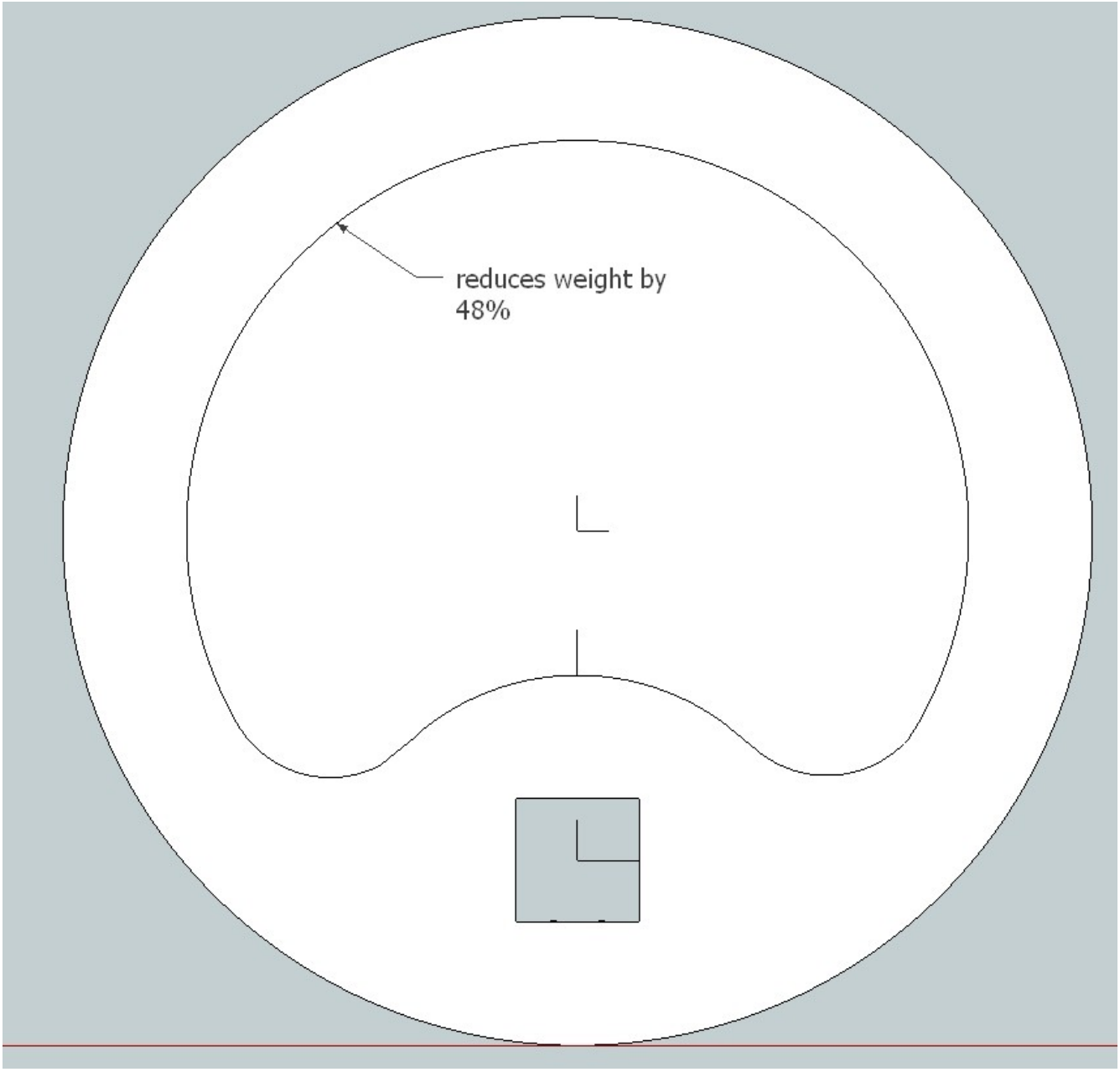
I only did 1 round of 220 grit and poly on the gear teeth. I could sand again with 220 grit on a 3/8" dowel with a slit on the drill press, and give a 2nd coat. This would not take too long and might help a little, plus putting Johnson Wax on the gear teeth. [I did this]

I don't think a round bearing would help much and it would be a lot of work to do it.

So, that leaves reducing the torque required just to turn the 16 big cams. If I reduce the weight, this should help. One option is to make a round hole. This reduces the rotating weight by about a third.



To do this, I would have to scroll saw it, because a big Forstner bit would tend to rip out pieces of the plywood. If I have to scroll saw it anyway, why not take out more weight? Option below takes out 48% of the weight, or about half.



I scroll sawed all 16 cams, then applied red water dye to the cut marks, and dried in oven.

Debug After Final Assembly of all Painted/Stained Parts

Surprisingly, I had fewer issues that I expected on a model as complex as this one!

Hand Crank torque is pretty good and reasonable!

Bell not working right

It was not as loud as I expected and sometimes marble got stuck (hit ringer wood and fell back into the low point of the chute).

Went back to the elevator model, which I copied the bell ringer design from and found my slot for the rotating wood piece with the brass rod was not deep enough. It was not letting the rotating piece swing down enough.

Checked my Sketchup model, and I forgot to update that Sketchup model to the"as-built" design with the deeper slot!

I reworked the existing piece to match the old as-built model with the Dremel rotary cutter.

I also added some ¼" thick curved pieces in about 3 places to keep marbles from shooting out, especially when the model is hand-cranked to an excessive speed.

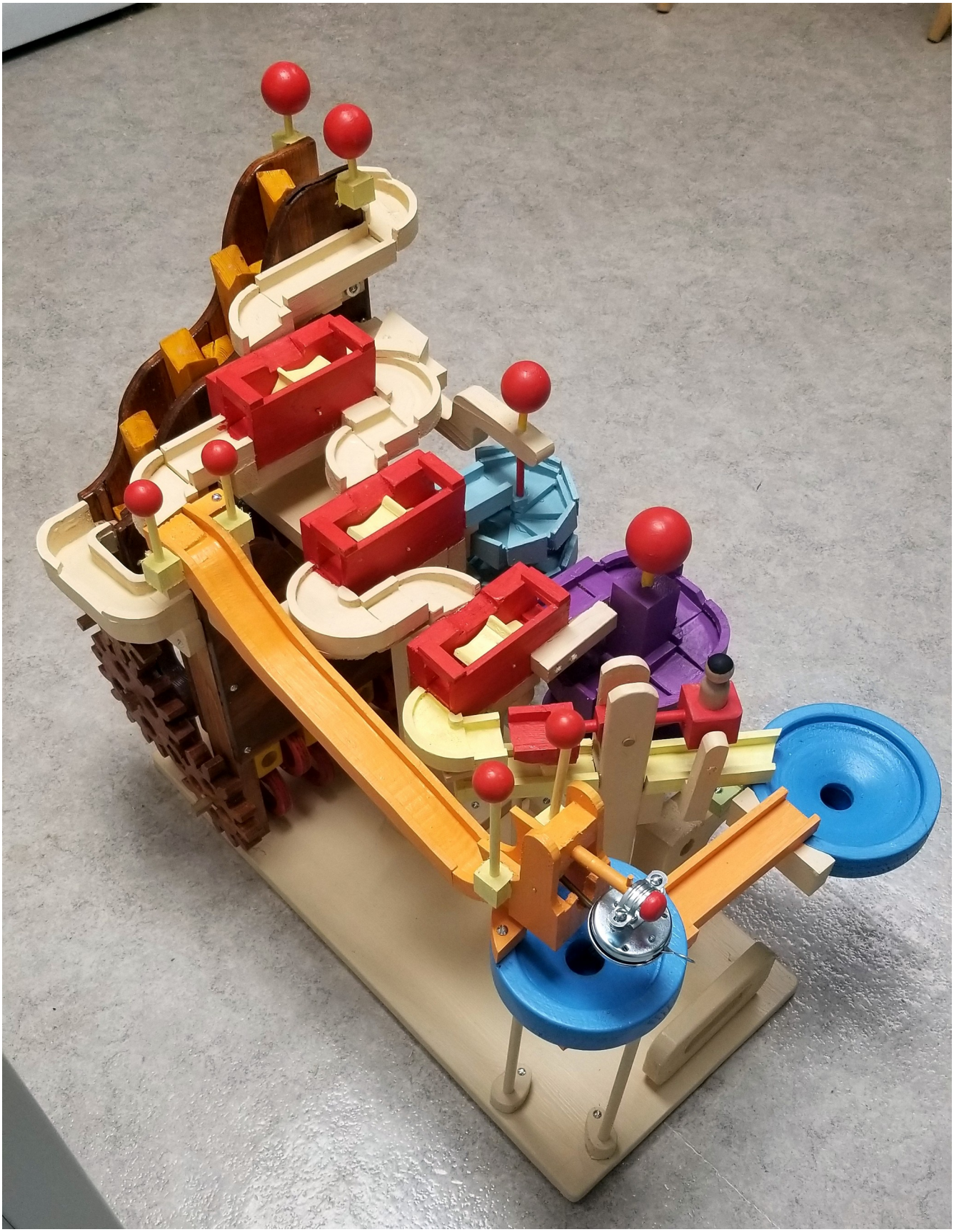
Bugs Mostly Worked Out January 31, 2024

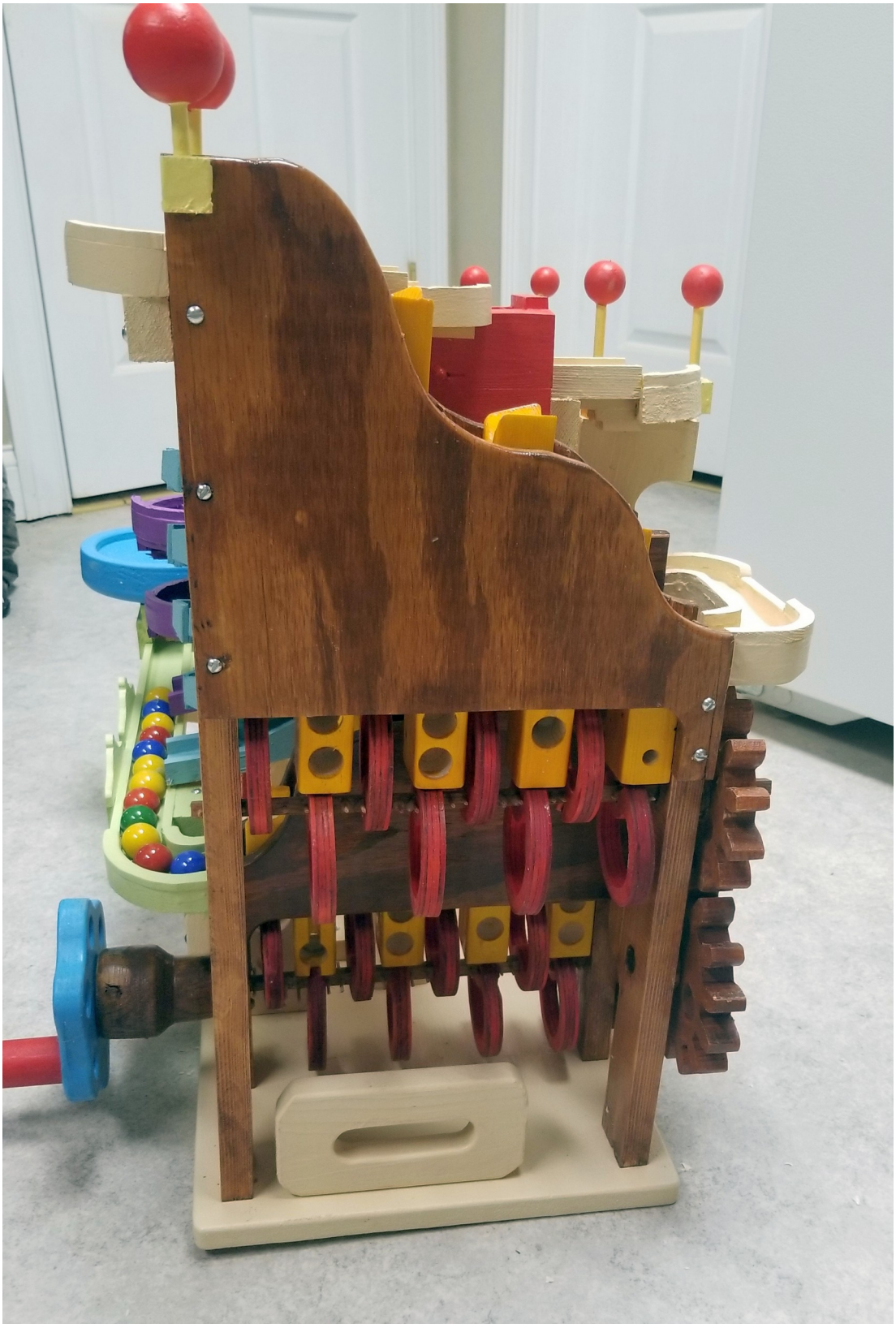
Looking back, here are the key dates for this project.

November 27, 2023	1st Concept Sketch in Sketchup
January 3, 2024	Started to build Proof-of-Concept
January 31, 2024	Project Completed

I ran the model for quite a few minutes, including trying to crank at an excessive speed. If you go way too fast, some marbles will jump out at loading point, but I judged that to be OK.

Photos of Finished Project 1/31/2024





Sketchup Warehouse

I uploaded a copy of the model to the warehouse.

http://tinyurl.com/4sce6v4r

Or use this link.

YouTube Video

I made a YouTube video of the model in action.

https://www.youtube.com/watch?v=ag0ugenaNqc&t=1s

Or use this link.

Closing Thoughts on This Project

This was a fun project to design and build.

Some new things for me on this project were:

1. I changed how I made the elbows or 90 degree angles on the marble chute. I used to glue up several pieces like I learned on the Giant Marble Machine project. I switched to band sawing them and gluing them up. I prefer the band saw method now.
2. The bobbing bucket was a new item I had to design and debug.
3. The light blue circular staircase was a copy of the one I built on the Giant Marble Machine project. The purple circular staircase was a new design for me.
4. This was the 1st project I used a square shaft and square holes in the cams.

Grand kids and adults should both have fun operating this model!